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Colonization of Basket Samplers by Macroinvertebrates in Riffle Areas of 10 Newfoundland River Systems

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COLONIZATION OF BASKET SAMPLERS BY MACROINVERTEBRATES IN RIFFLE AREAS OF 10 NEWFOUNDLAND RIVER SYSTEMS

by

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Colonization baskets were placed in a number of riffle sections of 10 river systems on the east and southeast coasts of insular Newfoundland. Results showed high net spinning trichopteran biomass in fall samples and high ephemeropteran biomass in spring samples. Chironomids were the most abundant group numerically, but not volumetrically, at both sampling times. Numbers and biomass of filter feeding trichopterans increased with increasing water velocity up to 50 cm s^{-1}, but at higher velocities decreased sharply, as did chironomid numbers. Simulid numbers increased significantly at higher velocities, whereas ephemeropteran numbers and weight showed little change relative to velocity. There was evidence that areas of lentic waters increased production of invertebrates, especially filter feeding trichopterans, probably due to increased output of seston. This gave rise in some rivers to upper stations below headwater lakes being more productive than downstream stations, in contrast to many previously reported studies on rivers less influenced by lakes, where generally is shown a gradual downstream increase in invertebrate production. The three southern Avalon Peninsula rivers had the lowest overall aquatic invertebrate biomass totals. The results suggest that important interacting factors influence diversity and production in the riffle areas. These include velocity effects, and the distance of the station downriver from a pond or lake, which regulates sources of fine and coarse particulate matter, directly controlling the presence of the various functional groups.

RÉSUMÉ

Thonney, J-P., R. J. Gibson, and K. G. Hillier. 1987. Colonization of basket samplers by macroinvertebrates in riffle areas of 10 Newfoundland river systems. Can. Tech. Rep. Fish. Aquat. Sci. 1558: v + 43 p.

Des paniers de colonisation ont été placés dans diverses sections de hauts-fonds de dix réseaux hydrographiques des côtes est et sud-est de Terre-Neuve. On a noté une biomasse nette élevée de trichoptères tissant des abris, dans les échantillons d'automne et une biomasse élevée d'éphéméroptères dans les échantillons de printemps. Au cours des deux périodes de prélèvement, les chironomidés étaient les plus abondants en nombre, mais non en volume. Le nombre et la biomasse des trichoptères filtreurs augmentaient en fonction de la vitesse d'écoulement, ceci jusqu'à 50 cm s^{-1}. Aux vitesses plus élevées, ces paramètres et le nombre de chironomidés, déclinaient abruptement. Le nombre de simulidés augmentait de façon appréciable aux vitesses élevées tandis que le nombre et la masse des éphéméroptères variaient

peu en fonction de la vitesse d'écoulement. Selon certains indices, les zones d'eau calme correspondaient à une production accrue d'invertébrés, notamment les trichoptères filtreurs, probablement suite à une production accrue du seston. Ainsi, les stations d'amont de certains cours d'eau, situées en aval des lacs de tête, étaient plus productives que les stations d'aval. Cela est à l'opposé des résultats de certaines études portant sur des cours d'eau, moins influencés par les lacs, où l'on note généralement une augmentation graduelle de la production d'invertébrés en direction de l'aval. Les trois cours d'eau de la partie sud de la presqu'île d'Avalon présentaient les plus faibles totaux de biomasses d'invertébrés aquatiques. Les résultats obtenus portent à croire à l'existence d'importants facteurs interreliés influant sur la diversité et la production dans les zones de hauts-fonds. Ceux-ci comprennent notamment les effets de la vitesse d'écoulement et la distance de la station à un lac ou un étang d'amont qui agit sur les sources de fines et de matières grossières et régit ainsi directement la présence des divers groupes fonctionnels.

INTRODUCTION

There are many factors which control the distribution and production of aquatic invertebrates in a lotic system. Important parameters include current speed, substrate type, dissolved substances, food availability, and competition between species (Hynes 1970). Downstream changes occur in the habitat which in turn determine the relative importance of sources of energy input, types of nutrients, trophic strategies of the members of the faunal community, and faunal diversity. In the river systems of insular Newfoundland, there is a sparse faunal assemblage compared to the continental land mass due to geographic isolation (Larson and Colbo 1983). However, land masses between lakes and rivers are not effective barriers for most groups present. Thus, occurrences of species between various watersheds should show high overlap, although distribution patterns are determined by the particular characteristics of each watershed.

The objective of this study was to characterize the aquatic invertebrate faunal assemblages and to compare their relative abundances from 10 insular Newfoundland river systems. This information will then be related to instream conditions in order to determine possible patterns of occurrence and sources of nutrients from factors inherent to each system. As well, the results will be integrated into a predictive salmonid productivity model for an ongoing experimental rivers program being conducted by DFO.

STUDY SITES

The 10 study rivers were located in five main areas on the island (Fig. 1). In Area 1, Northwest Brook (48°44'N 54°03'W) runs into Northwest Arm, then Alexander Bay through to Bonavista Bay. Southwest Brook (48°37'N 53°58'W) and Wings Brook (48°38'N 53°55'W) flow through Southwest Arm and Alexander Bay to Bonavista Bay (Area 1). In Area 2, Southwest River (48°19'N 54°10'W) and Salmon Brook (48°23'N 54°12'W) flow into Clode Sound and then into Bonavista Bay. North Arm River (47°23'N 53°10'W) flows into Conception Bay on the northern Avalon Peninsula (Area 3). Main Brook (47°05'N 55°17'W) is part of the Tides Brook system located on the Burin Peninsula which flows into Placentia Bay (Area 4). Northeast Brook, (46°46'N 53°22'W), Drook River (46°41'N 53°15'W), and Freshwater River (46°39'N 53°46'W) are proximal rivers on the south coast of the Avalon Peninsula which drain into Trepassey Bay (Area 5).

Stations were sampled in September in Wings Brook in 1982 and 1983, in Southwest Brook in 1982 (Fig. 2), in Northwest Brook in 1982 (Fig. 3), in Salmon Brook and Southwest River in 1982 (Fig. 4), in North Arm River in 1983 (Fig. 5), in Main Brook, of the Tides Brook system, in 1983 (Fig. 6), and in Freshwater River and Drook River (Fig. 7) and Northeast Brook (Fig. 8) in 1984.

In addition, samples were taken in Northeast Brook, Freshwater River, and Drook River in May 1985. The numbers of samplers are shown in the Appendix.

Also, some Surber samples were collected in the lower parts of Freshwater River and Northeast Brook in October 1984 (D. Scruton, Department of Fisheries and Oceans, P.O. Box 5667, St. John's, Newfoundland A1C 5X1, pers. comm.).

MATERIALS AND METHODS

Colonization baskets were made of Vexon plastic screening (mesh size 1.9 cm in diameter) cut to form a 10-cm high by 20-cm wide cylinder, with the lid and bottom of the same material. Baskets were filled with smooth, rounded stones of a fairly uniform size, picked from a beach. In 1982 the mean number of rocks required to fill each basket was 26.8 (S.D. 5.3) with a mean rock diameter of 5.6 cm (S.D. 0.5). From 1983 to 1985 numbers were 66.7 (S.D. 8.4) per basket, with a mean rock diameter of 4.0 cm (S.D. 0.5). At each site sets of four to six baskets were installed within a chosen riffle of the river at a water depth which would ensure adequate basket coverage. The samplers were placed on the bottom and secured with a line to a fixed structure (e.g. boulder or branch) to minimize loss of baskets due to flooding, and left in place for a period of one to two months. Upon retrieval, depths of each basket were recorded and the water velocities measured in front of each basket using a Hiroi acoustic current meter. The baskets were removed by placing a dip net immediately downstream of the basket and slowly lifting the sampler with the dip net cradling it out of the water. Any invertebrates falling from the basket into the net were included in the sample, although these were few. The baskets were cut open and the resident invertebrates washed and scraped from each rock and basket using a stiff bristle brush. The sample was placed in 95% ethanol in appropriately labeled bottles.

In the laboratory, all basket samples were sorted with the aid of a dissecting microscope. Macroinvertebrates removed from the inorganic substrate and plant material were represerved in 70% ethanol. The invertebrates were subsequently identified to the level of Family for the most frequently encountered groups and Class or Order for the less common groups. The numbers of invertebrates in each taxon were counted, the volumes measured by volumetric displacement, and the wet and dry weights measured to the nearest 0.01 g. Trichopterans were removed from their cases before volumetric and weight measurements were made. Select taxa were grouped according to their respective feeding modes following the trophic classification described by Merritt and Cummins (1978).

At each Surber sampling site, replicate benthic samples were collected using a 30.5 x 30.5 cm sampler with a 571 m mesh. Samples were collected from cobble substrate in riffle areas by placing the sampler over a selected area and all the rocks enclosed removed and washed off in the mouth of the Surber net to dislodge all attached organisms. After all large substrate had been removed, the remaining fine material (fine gravel, sand, or silt) was agitated for about 30 seconds. All material retained by the Surber net was preserved in 75% ethyl alcohol (Pope and DeGraaf 1985).

For the basket totals within a station, the mean (and standard deviation) frequency of occurrence by both number and weight were tabulated for all groups. Predominant groups were those contributing greater than 10% by weight or number of the total invertebrates collected.

RESULTS

The numbers and volumes of the most commonly occurring aquatic invertebrate groups from all samples are presented in Figure 9. Overall, net spinning (filter feeding) trichopterans were the greatest contributors to total volume in the fall samples. Ephemeropterans showed their highest biomass in the spring but in the fall there were more small individuals present than in the spring. Chironomids were numerically the most common taxa in both the spring and fall.

There was no linear relation between the total number of invertebrates and water velocity (Fig. 10). The frequency of occurrence of the most important invertebrate groups relative to water velocity is shown in Figure 11. In the fall, baskets showed an increase in filter feeding trichopterans with increasing velocity up to 40-49 cm s^{-1}, but at 50^{+} cm s^{-1} a sharp decrease occurred. At these two fast water collecting stations there were no chironomids present, a group which was the most common numerically in slower flows. Contribution from ephemeropterans showed no significant pattern relative to water velocity in the fall, but simulid numbers increased with increasing water speed present in the faster water stations but were absent in waters flowing less than 39 cm s^{-1}.

In the spring, filter feeding trichopterans and ephemeropteran volumes were greater at velocities above 50 cm s^{-1}. Predictably, groups usually associated with slower water were more common in those spring samples with slow flows (i.e. chironomids, case building trichopterans).

The mean number and wet weight of all organisms collected from each station is summarized in Figures 12-14. In the 1983 fall samples the upper stations of the Wings Brook system of Area 1 had very much higher volumes than the lower station, with a mean volume of 1.57 ml in Wings upper, and 1.56 ml in Blue Hill, compared with 0.68 ml at the Wings lower station (Fig. 12). The upper stations of Southwest Brook also held more organisms than did the lower one as did the stations on Southwest River. There were fewer but larger individuals collected in the lower Northwest Brook station (amphipods) compared to the dominant group at the upper station (filter feeding trichopterans). In Area 2 Salmon Brook stations had very similar group compositions, with mean volumes of 0.44 ml and 0.46 ml and appeared to be slightly greater than stations in the Southwest River, with mean volumes of 0.25 ml in the upper and 0.34 ml in the lower stations. In Area 3 the North Arm River samples had a relatively high mean volume of 1.30 ml. The three proximally located Tides Brook stations in Area 4 showed relatively low mean volumes of 0.29 ml to 0.58 ml.

Samples from the three rivers located in Area 5 in the fall of 1984 were less productive in terms of invertebrate numbers and weight compared to the previous rivers (Fig. 13) with stations in Freshwater River having somewhat higher mean volumes (0.19 ml to 0.72 ml) than those in the other two rivers (up to 0.41 ml in Drook, and up to 0.19 ml in Northeast). Drook River samples showed fluctuating numbers but a gradual biomass increase with increasing distance upstream. In this system the downstream section is in a long valley with no ponds, which do however occur in the headwaters. Freshwater River invertebrate numbers also fluctuated, but irrespective of the station's position along the river, although the highest biomass totals were found in two downstream stations. Northeast Brook totals decreased from the mouth to Station 5 (approximately 2 km from mouth), but then increased to two to three times the biomass and numbers in the three upstream stations (Stations 6-9). Of the three systems Freshwater River has the greatest number of ponds through the system.

Spring totals (1985) were much higher than fall totals for the two Drook River stations and two of three Freshwater River stations, but were similar between the seasons in Northeast Brook, except for a higher spring biomass total at Station 4. Freshwater River and Drook River appear to be more productive than Northeast Brook, with mean sample volumes of 0.17 to 1.08 ml in Freshwater and 0.72 to 1.15 ml in Drook, compared with up to 0.64 ml in Northeast.

Detailed results follow.

FALL RESULTS

Area 1

Wings Brook: In 1982 the lower station was dominated volumetrically by ephemeropterans and numerically by case building trichopterans (Fig. 15). In contrast, at the two upper stations filter feeding trichopterans and secondarily ephemeropterans were the greatest contributors by volume, whereas chironomids dominated numerically. However, the number and volumes of invertebrates collected in upper Wings Brook were much higher than in Blue Hill and lower Wings Brook. In 1983 there were four important groups in the baskets of the lower Wings station, but the important groups, volumetrically, in Blue Hill Brook and upper Wings Brook were filter feeding trichopterans and Odonata, a group not collected in 1982. Ephemeropteran volumes and numbers remained constant in Blue Hill between years but were lower in lower and upper Wings Brook in 1983 compared to 1982. Chironomids were numerically dominant in 1983 samples. Thus, in 1983 the two upper stations showed some similarity in the proportions of invertebrates present. Annual comparison revealed a great annual difference in the biomass of Odonata within stations. However, since individuals are large and occur in low density a small change in number would greatly affect biomass totals. Lower Wings and Blue Hill Brook stations appeared to be more productive in 1983 compared to 1982. However, samplers were in higher water velocities in 1983 ($\bar{x}$ = 46.7 cm s^{-1}) than in 1982 ($\bar{x}$ = 20.3 cm s^{-1}).

Southwest Brook: Chironomids were the most common group numerically and net spinning trichopterans volumetrically in both stations. Odonata and ephemeropterans were more common in the upper station (Fig. 16). The biomass of aquatic invertebrates found at the lower station was greater than at the upper station.

Northwest Brook: The dominant group at the upper (Boatswain's Brook) station was filter feeding trichopterans but this group was less abundant at the lower station (Fig. 16). Amphipods were the highest contributor by volume at the lower site, but were absent from the upper station. The overall number of aquatic invertebrates was higher in the upper site but the biomass was lower than at the lower station. The water velocity at the lower station was much slower (18 cm s^{-1}) than that of the upper station (43 cm s^{-1}).

Area 2

Salmon Brook: Mean biomass and numbers were similar between the two stations. Filter feeding trichopterans and Odonata were volumetrically similar and case building trichopterans and chironomids were numerically similar in the lower station (Fig. 17). Filter feeding trichopterans were by far the largest contributors to volume followed by case building trichopterans in the upper station. Chironomid numbers were much higher at the upper station but the proportion of Odonata biomass was lower than at the lower station.

Southwest River: The contribution of filter feeding trichopterans was similar at both sites, but Odonata volumes at the lower site were much greater. Chironomids were the most abundant group at both stations. Velocities were relatively slow (17 cm s^{-1}) at both stations, and mean volumes low.

Area 3

North Arm River: The highest number of individuals collected were chironomids and ephemeropterans (Fig. 18). Although few in number, amphipods and Odonata made up a large part of the total weight of invertebrates at this station which had a relatively fast flow (51 cm s^{-1}).

Area 4

Tides Brook: In all three of these proximally located stations chironomids were dominant numerically, with filter feeding trichopterans contributing the greatest proportion of the total weight (Fig. 19). Odonata were found only at Station 2, while setipalp Plecoptera were absent from only this station. Ephemeropterans were secondary contributors at all three stations. Station 3 had the highest total number of organisms due to the presence of chironomids, but had the lowest total volume of the three stations.

Area 5

Northeast Brook: In seven out of nine riffles sampled net spinning trichopterans were the predominant invertebrate group by weight (Fig. 20). At the other two stations (Stations 3 and 8) ephemeropterans were the largest contributors and filter feeding trichopterans the second most important group. The station with the lowest proportion of filter feeding trichopterans

(Station 8) had the highest velocity (56 cm s^{-1}), but was located in a headwater stream not proximal to a pool or pond. Station 7, with the second lowest invertebrate biomass and total numbers (of which ephemeropterans and net spinners predominated) had the slowest flow (15 cm s^{-1}).

Freshwater River: As was observed in Northeast Brook samples, the predominant group by weight at most stations was the filter feeding trichopterans which were important contributors at all conditions of depth and water velocity. Ephemeropterans were more dominant volumetrically at Stations 1 and 7 (Fig. 21). Total chironomid numbers were marginally higher than net spinner numbers. At only one station (Station 5) were simulids a major contributor. Amphipods were the second most important group by weight at the station closest to the river's mouth (Station 1). Overall aquatic invertebrate numbers and weights varied greatly between stations within the river. The lowest total was found for the lower station (Station 1) and the highest in one of the upper stations (Station 8).

Drook River: There was a notable absence of filter feeding trichopterans in the downstream three of the seven riffles sampled in this river, as compared to the previous two southern Avalon Peninsula rivers (Fig. 22), related probably to the absence of ponds in this lower section. Ephemeropterans were the prominent group in these three lower stations. Three upper stations (Stations 4, 5, and 6) located downriver of ponds featured a large proportion of filter feeding trichopterans by weight. In the uppermost station (Station 7) chironomids were most important by both weight and numbers. Case building trichopterans were secondary contributors at Stations 4-7 but case builders were notably absent from Stations 1-3. Two of the upper stations (4 and 5) had aquatic invertebrate numbers and weights that were slightly higher than the other stations.

Surber Sampler Results

Results of Surber samples collected from Northeast Brook (Fig. 26) reflected the samples collected from colonization baskets. Filter feeding trichopterans were dominant volumetrically while chironomids were most abundant. Ephemeropterans and filter feeding trichopterans were also numerically important to the invertebrate totals. Surber samples for Freshwater River contained case building trichopterans, amphipods, and various forms of burrowers (annelids, hirudinoids, nematodes, etc.) showing a marked contrast to the colonization basket samples, which were dominated primarily by filter feeding trichopterans. Numerically, chironomids were the dominant group in Freshwater River.

SPRING RESULTS

Drook River

At the two stations sampled in May 1985, the total numbers and weights of aquatic invertebrates were much greater compared to the fall totals (Fig. 23).

Chironomids (by number) and ephemeropterans (by weight) were the most common groups with predatory trichopterans of secondary importance volumetrically. The water velocity at Station 1 was more than twice that measured in the fall and at Station 3 it was three times that measured during fall 1984 sampling.

Freshwater River

Two of the three stations (Stations 1 and 5) had filter feeding trichopterans as the largest contributor by weight while simulids occurred in lesser proportions (Fig. 24). Chironomids were most common numerically at these two stations. This pattern of occurrence was similar to that observed in the fall of 1984 at these stations. Both stations had relatively high numbers and weights of invertebrates per basket compared to the third station (Station 6), which had a much slower flow and contained primarily simulids by number and ephemeropterans and case building trichopterans by weight compared to the high proportion of filter feeding trichopterans observed in the fall 1984 sample. Spring flows at Stations 1 and 5 were three times as fast and water depth greater than during fall sampling, whereas water velocity and depths were less during spring compared to fall sampling at Station 6.

Northeast Brook

Invertebrate biomass and abundance were low in the two lower stations sampled in May (Fig. 25). Simulids and filter feeding trichopterans were the dominant groups in the two faster water stations. Station 3, which had one-third the water velocity of Stations 1 and 4, had ephemeropterans as the most important group (by weight). The proportions of filter feeding trichopterans were much lower at the two lower stations than at the same stations in fall 1984. Depths were less at Stations 1 and 3 in the fall and velocities at Stations 1 and 4 were one-third of those measured in the spring.

DISCUSSION

Large differences in the relative proportions of invertebrate groups were observed between riffle areas of a river as well as between rivers. Obviously, responses to differences in the microenvironment shown by members of these benthic communities reveal some of the subtle complexities from even minor changes in environmental conditions. Since microdistribution of benthic invertebrates is the outcome of a series of responses to a set of interacting variables, the variables inherent to each riffle (Minshall and Minshall 1976) must be ordered in terms of importance to determine which most significantly affect invertebrate production and diversity.

Substratum appears to be one of the most basic aspects of stream habitat reflecting or determining current flow, refuges or food distribution (Allan 1975). The importance of substratum and water velocity with respect to invertebrate production has led to a number of studies aimed first at identifying and quantifying stream benthos and then attempting to relate this invertebrate presence and abundance to stream conditions (Hynes 1970; Allan 1975; Mason et al. 1972; Walter 1978; Reice 1980). Increased substratum complexity leads to greater species richness because congeners differ in habitat preferences (Allan 1975) and within a rather wide range of current velocities, manipulation of the substratum greatly affects the resident faunal assemblage (Minshall and Minshall 1976; Reice 1980). The existence of stream benthos in substrate specific associations confined to fairly well-defined types of substrate shows them generally to be more abundant on one type than the other (Hynes 1970; Walton 1978). To some extent, the functional groups have current preferences, but work by Minshall and Minshall (1976) found that within a range of conditions normally measured in their study area, water velocity was itself not of primary importance in the microdistribution of fauna, but related to the nature of the streambed, determines substratum diversity. Since much of the complexity of the substratum is contained in any 0.1 m^2 patch (Allan 1975) the larger the sites compared the less they would tend to differ in faunal assemblage. Longitudinal change in diversity and abundance of aquatic organisms would then tend to be a faunal adjustment rather than a substrate-related characteristic.

Another factor demonstrated as being important to invertebrate production is the level of instream nutrients. Studies by Cushing (1963), Ulfstrand (1968), and Williams and Williams (1979) showed that the quantitative distribution of aquatic invertebrate larvae generally follows the quantitative distribution of food. Given a rich supply of suspended nutrients from an upstream source, however, one part of the stream which is similar in physical and chemical conditions to another part may support a much greater bottom fauna population (Ulfstrand 1968). Roby et al. (1978) found that most of the variation in the number and types of organisms correlated with increases in suspended organic detritus. The sources of energy input and types of nutrients entering each riffle change relative to upstream changes in habitat. Sections of river that have an influx of a specific size and type of food are conducive to a particular trophic level of feeder, inducing fluctuations in the occurrence of a functional group within the same drainage system and more specifically between proximal stations of a given system. A rich supply of suspended food generally favors the development of large populations of filter feeding Diptera (simulids, chironomids) and Trichoptera. Williams and Williams (1979) found filter feeding organisms scarce in portions of a river lacking in upstream depositional waters such as deep pools, ponds, or lakes, which related directly to low levels of suspended detritus. Stream outlets from standing waters localize production of filter feeders, whose passive feeding mechanism is ideal for entrapment of the rich supply of seston in these areas (Hynes 1970). Due to the entrapment of nutrients over a short distance of stream the effect upon invertebrate diversity and production from these nutrient-rich waters is limited in small streams to the first few meters from the outlet (Oswood 1979; D. Larson pers. comm.) However, over stream orders 1 through 4 in a southern Appalachian stream, Ross and Wallace (1983) showed that benthic filter feeders had a progressively smaller impact on the seston as stream size increased, related to higher transport velocities, which reduce the rates at which filter feeding caddisflies can process the organic inputs to a given reach of stream. In a sixth order boreal river in Quebec, Gibson et al. (1984) found that an upstream lake increased production of invertebrates at least over the 4.3 km examined downstream. Therefore, proximity to lakes and ponds, the quality and quantity of seston related to the type of lake, and the size of the river, are important factors regulating filter feeder production. The Wings Brook system is an example of a situation in which the upper stations just down stream of a lake produced large quantities of filter feeders. At the lower station, however, (Fig. 2), there was a lower number of filter feeders. Similarly, Southwest Brook (Fig. 2), Northwest Brook (Fig. 3), Tides Brook (Fig. 6), and Salmon Brook (Fig. 4) showed higher proportions of filter feeders at upper stations, which were located proximal to ponds or lakes, compared to downriver stations. The three lower stations of Drook River were located away from depositional waters and subsequently few filter feeders were found in the samples. However, there was a large proportion of shredders at these sites, suggesting that either allochthonous sources or the thick mats of Fontinalis sp. present were providing coarse food particles and habitat for coarse particulate organic matter (CPOM) feeders in these riffles. Stations 4-6 were located just downstream from depositional waters and the high proportion of filter feeders may be reflecting a rich source of fine versus coarse particulate food at these stations. The greater biomass at upstream compared to downstream stations is a reverse of the usual situation, illustrated in the 'stream continuum' hypothesis by Vannote et al. (1980), and most likely related to distance from lentic waters. The large number of ponds and lakes in most Newfoundland systems differs from the 'normal' trunk river system common elsewhere (Horton 1932).

The three southern Avalon Peninsula rivers are an example of the way in which poor sources of allochthonous nutrients affect the resident benthic invertebrate composition. Freshwater River, which flows through sphagnum bogland virtually devoid of shrub and canopy and instream vegetation for most of its length, had an aquatic invertebrate fauna dominated by filter feeders. Drook River, also seemingly lacking in allochthonous sources of large food particles, has a very dense covering of instream vegetation (mostly Fontinalis sp.) providing good cover for ephemeropterans, case building trichopterans, and chironomids, and possibly entrapping detritus suitable as food. Northeast Brook has a more moderate growth of instream vegetation resulting in a preponderance of filter feeding trichopterans at most stations compared to levels of larger particle feeders such as Ephemeroptera. These three rivers showed the lowest numbers and volumes of aquatic invertebrates of all areas, due mainly to smaller numbers of chironomids captured here (which were usually numerically dominant in the other rivers). However, of the three rivers Freshwater River appeared to be the most productive, possibly related to the relatively greater number of ponds.

The seasonal productivity of each functional group relates closely to seasonal peaks of nutrients within a given drainage system. Hence, the highest density and diversity of trichopterans and dipterans usually occurs in the fall and to a lesser degree in the spring coinciding with increased flows and amount of nutrients (Larson and Colbo 1983). Other groups such as Plecoptera, Odonata, and Ephemeroptera generally have the majority of species in the nymphal stage in the spring with the lowest diversity and density in late summer. This pattern was not apparent at stations sampled in the spring of 1985 and fall of 1984. Those groups expected to show a seasonal increase actually decreased in Freshwater River and remained relatively unchanged in Northeast Brook and Drook River. The samples were collected late enough in the fall and early enough in the spring before emergence that the same population may have been sampled resulting in little distinction between seasons.

Seasonal changes in these groups might be more apparent if collections were made more frequently (i.e. monthly).

The study of aquatic invertebrate production using an artificial bottom is well documented, as is comparison of the effectiveness of the various sampling methods used in collecting benthos (Cummins 1962; Bell 1969; Crossman and Cairns 1974; Khalef and Tachet 1980). The planting of artificial bottoms suffers from the obvious disadvantage of artificiality and the performance of colonization baskets in collecting accurate quantitative samples has been questioned (Coleman and Hynes 1970; Calow 1972). Important considerations include: variation in the length of sampling time required for adequate representation is quite significant; baskets offer a more specialized habitat than the surrounding bottom; and competitive exclusion of drift organisms by resident invertebrates which rapidly colonize and utilize available space in the sampler. Sampling bias of colonization baskets compared to drift samples in favor of net spinning trichopterans versus ephemeropterans and plecopterans (coarser material feeders) has been observed (Gibson et al. 1984). This may have been a factor explaining the regularly high frequency of net spinners in many of our samples, seemingly irrespective of habitat type. These limitations notwithstanding, colonization baskets provide favorable habitat with uniform and reproducible substrate composition and area over controlled exposure periods and permit collection of a diverse fauna in the habitat of choice irrespective of the type of stream bed (Dickson et al. 1971). Thus artificial substrate samplers do not provide accurate assessment of actual standing crops found on the adjacent stream bed (Jacobi 1971) but provide a reasonably good measure of relative abundance and biomass of the predominant groups (Dickson et al. 1971). Since relative production of Newfoundland rivers may be regulated more by amount and types of lentic waters in the system than sources of allochthonous input, methods of comparing relative production of rivers by deriving indices for amounts of filter feeders present may be valid. In a Québec River, similar to many Newfoundland systems, Gibson and Galbraith (1975) and Gibson et al. (1984) showed that salmonid production was food limited and was related to the relative amounts of filter feeders present, so that such indices may prove useful for models predicting salmonid production in Newfoundland.

CONCLUSIONS

These results suggest that, in many river systems in insular Newfoundland, the type of organic nutrients entering a riffle may be the most important factor limiting distribution and production of lotic invertebrate fauna. The results suggest that invertebrate numbers and volumes are controlled by interactive conditions inherent to each microhabitat within a riffle, and separation of each functional group occurs by trophic level in relation to ecological, spatial or temporal requirements of the group. Because within stream comparison of riffles provided significant variability in numbers, biomass and diversity of aquatic invertebrates, little congruity of results between rivers was observed. The distance downstream of the sampled riffle from a source of lentic water combined with availability of CPOM appears to be critical in controlling the production of the different functional groups by reason of the available food size range. As opposed to the general trend of increasing production downstream, 6 out of 10 streams studied here showed greater numbers and volumes of invertebrates at the upper stations, due to their proximity to lakes or ponds.

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Symbols for Figures 9, 11-26 and Appendix

Symbol	Invertebrate Group
E	Ephemeroptera
Tp	Trichoptera (predatory)
Tc	Trichoptera (case builder)
Tf	Trichoptera (filter feeder)
S	Simuliidae
C	Chironomidae
Do	Diptera (other)
Ps	Plecoptera (Setipalp)
Pf	Plecoptera (Filipalp)
O	Odonata
Co	Coleoptera
B	Burrowers (i.e. annelids, hirudinids, nematodes, etc.)
H	Hydrocarina
A	Amphipoda
G	Gastropoda
P	Pelecypoda
Z	Zooplankton
Oth	Other (terrestrial drift; < 2% contributors)

Open columns represent numbers and hatched columns represent wet weights (g) (≡ volumes, ml). Bars represent standard deviations either side of the mean.

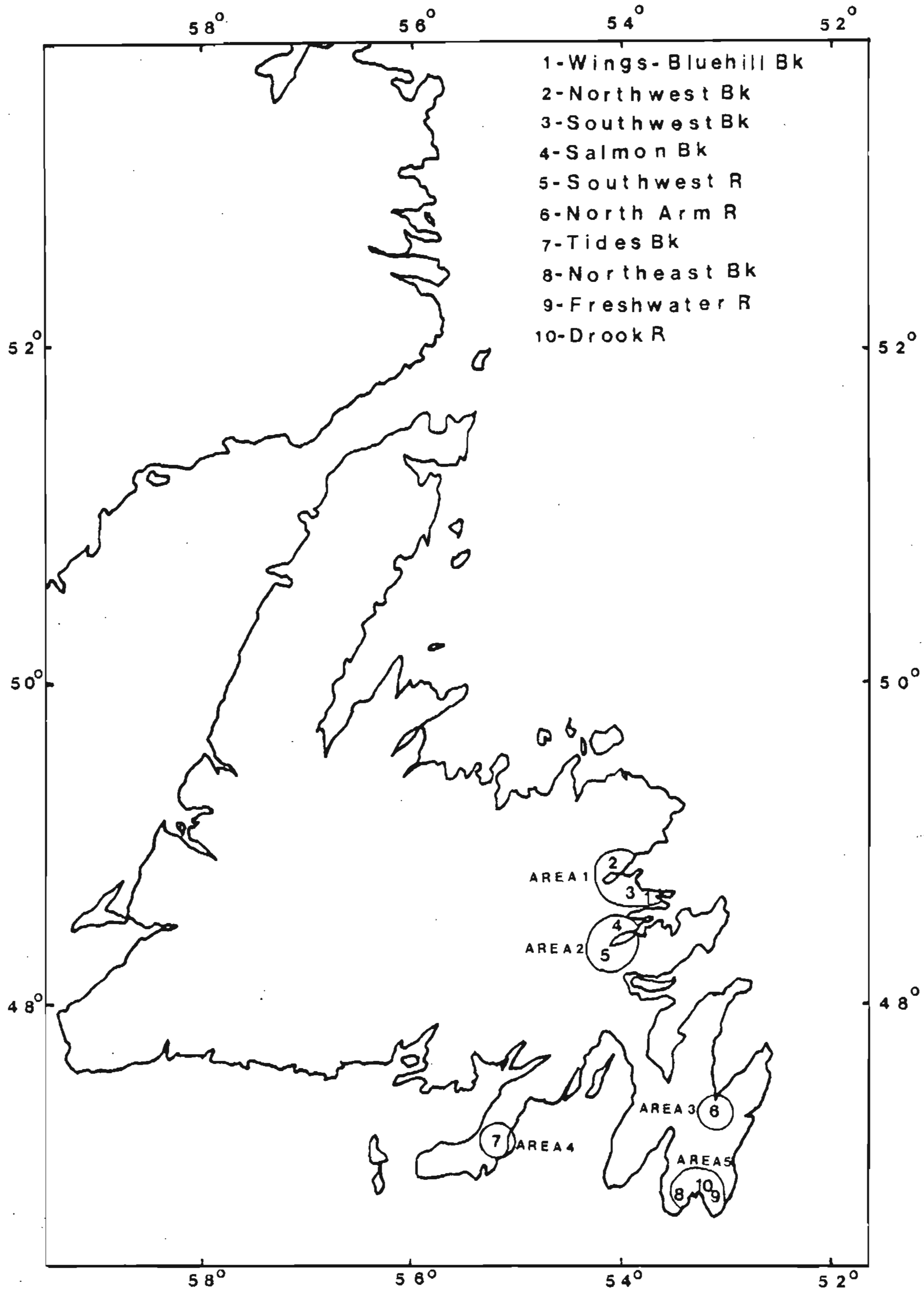

Fig. 1. Map of the five study areas in Newfoundland.

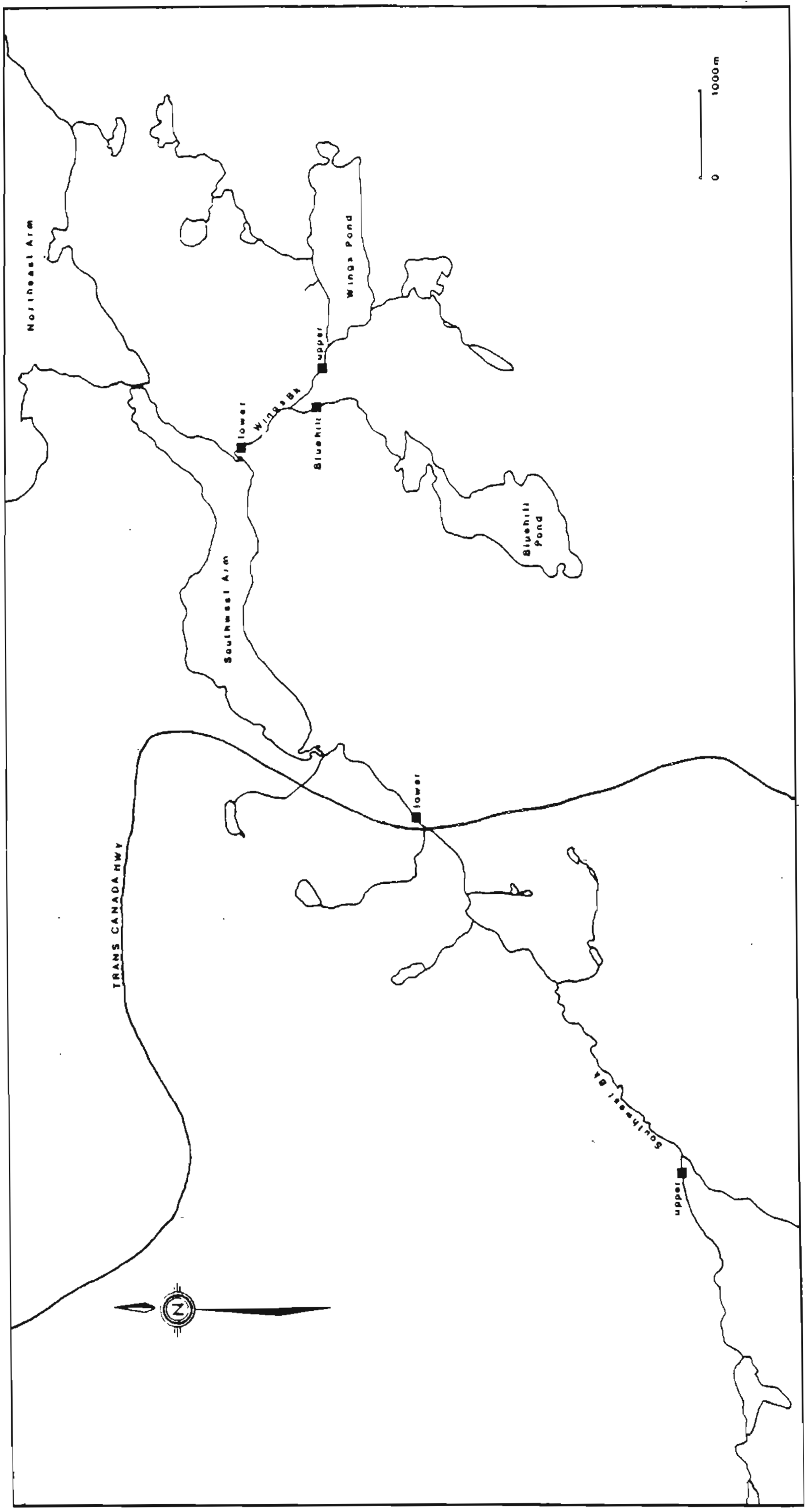

Fig. 2. Area 1 - Wings Brook and Southwest Brook stations.

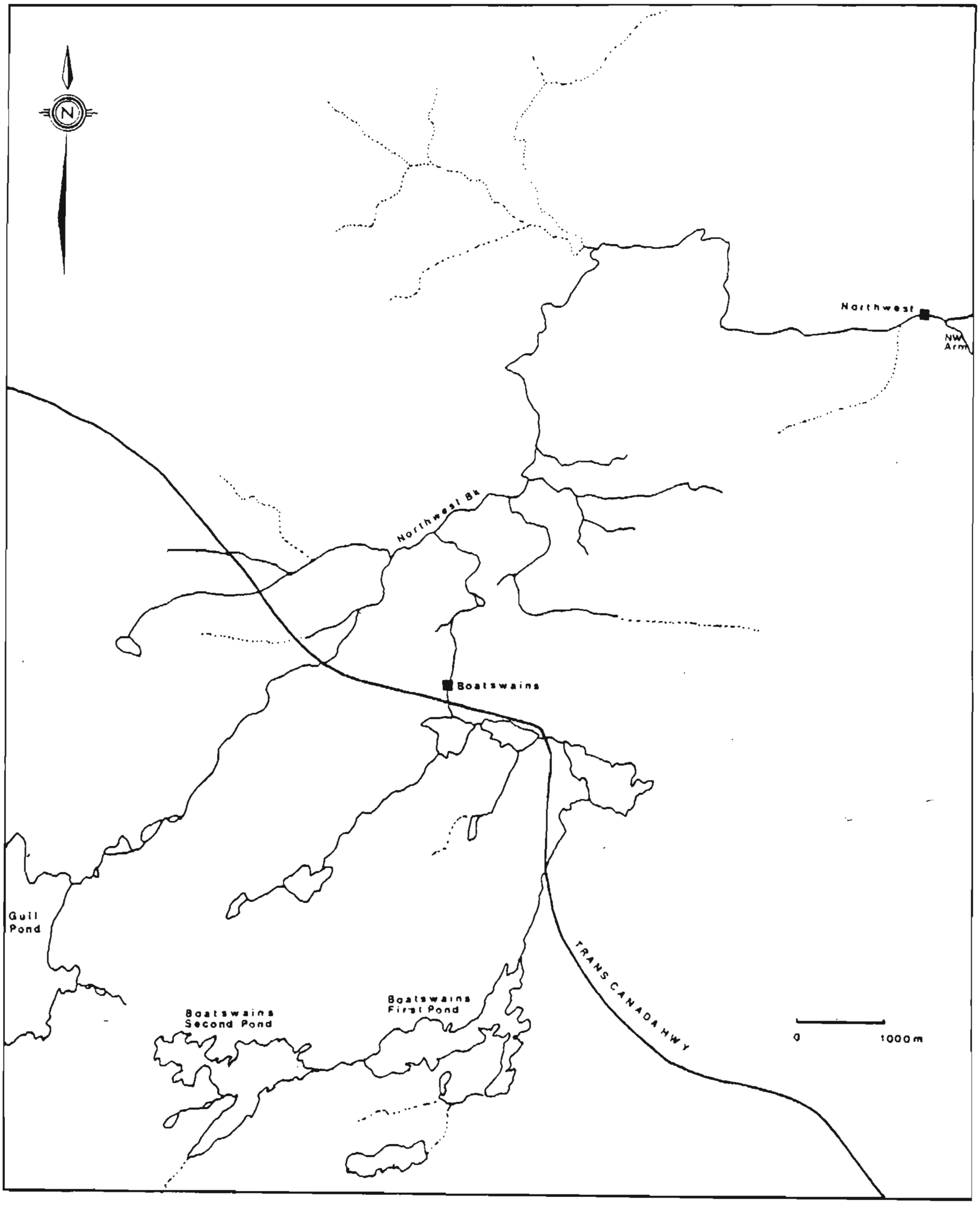

Fig. 3. Area 1 - Northwest Brook stations.

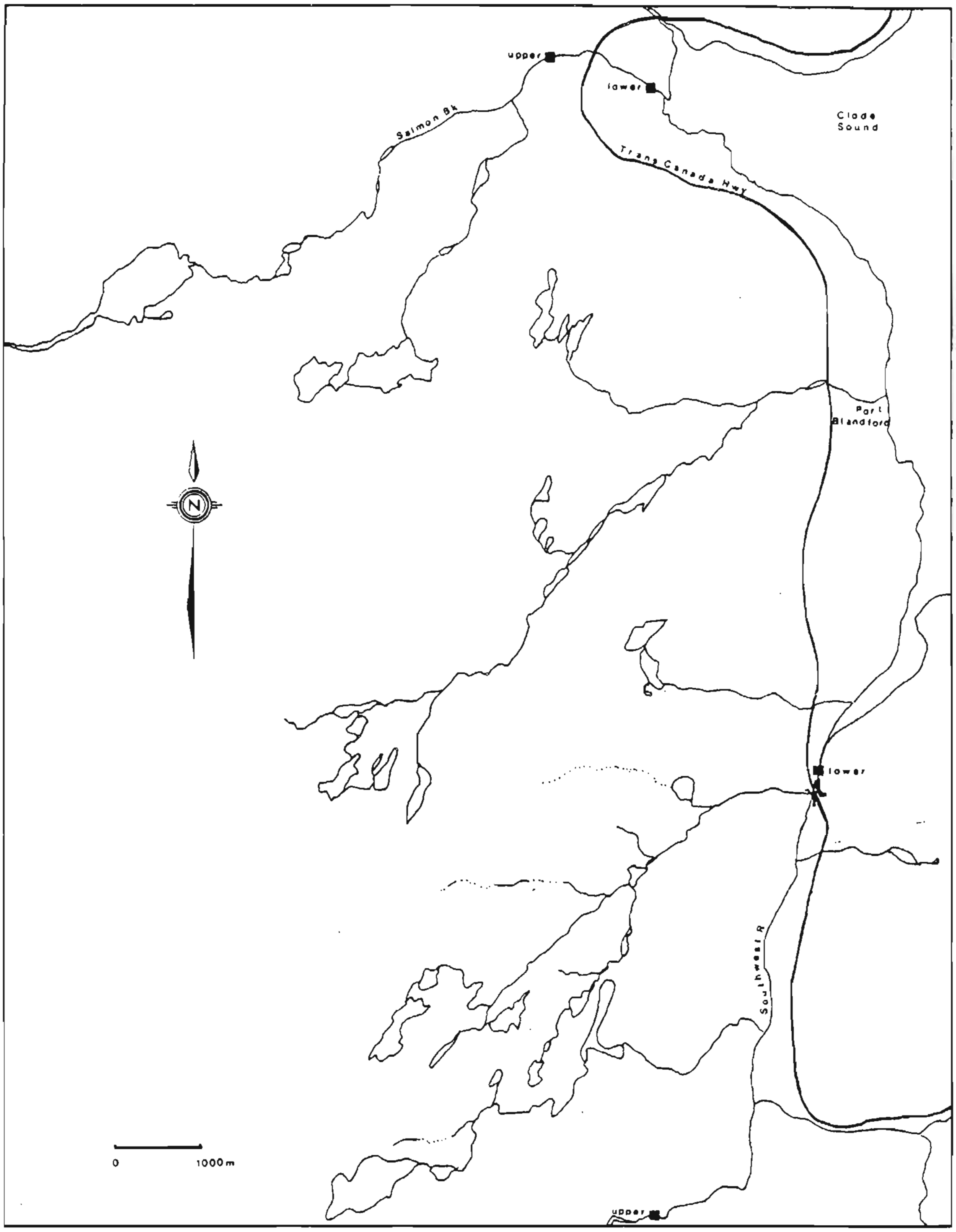

Fig. 4. Area 2 - Southwest River and Salmon Brook stations.

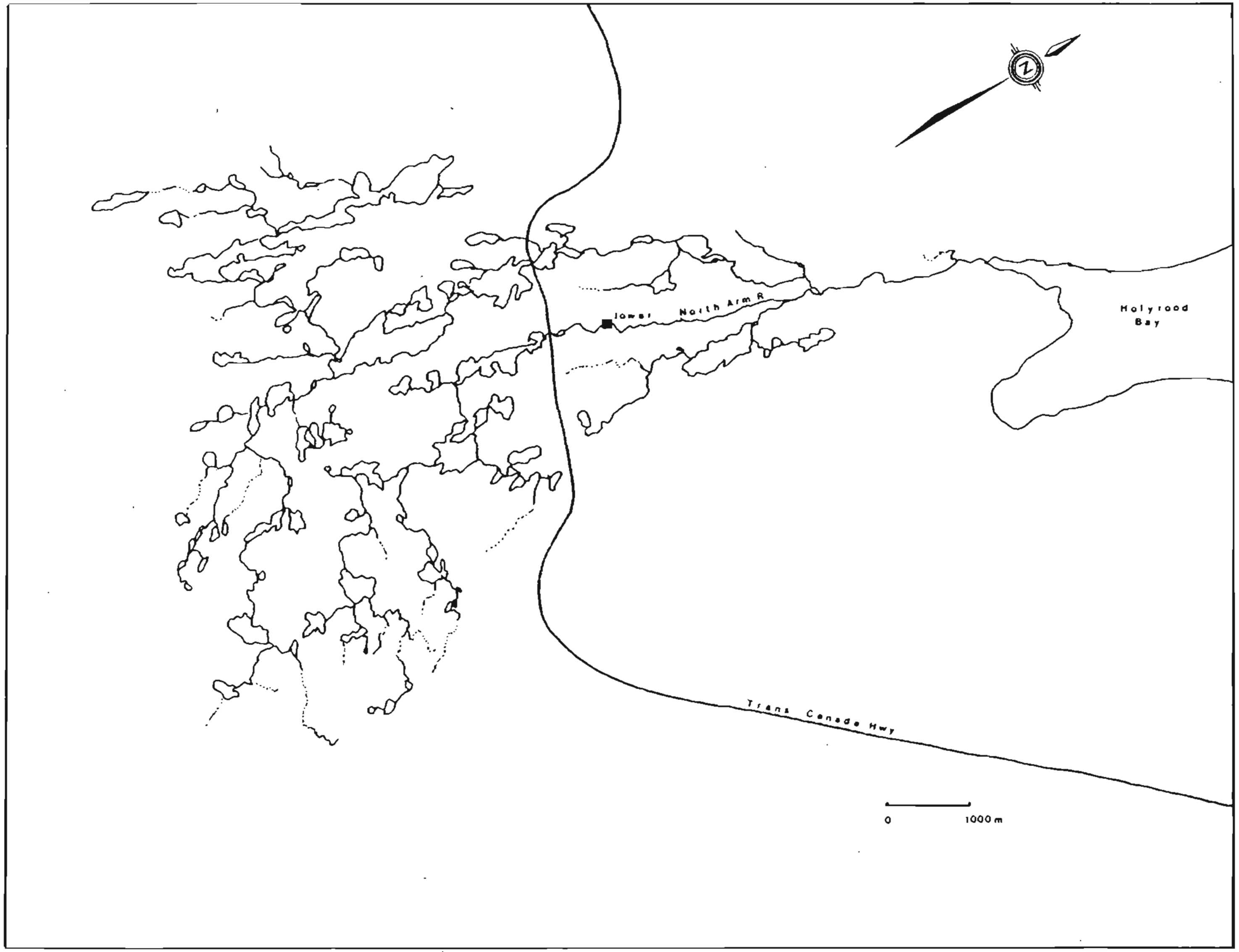

Fig. 5. Area 3 - North Arm River stations.

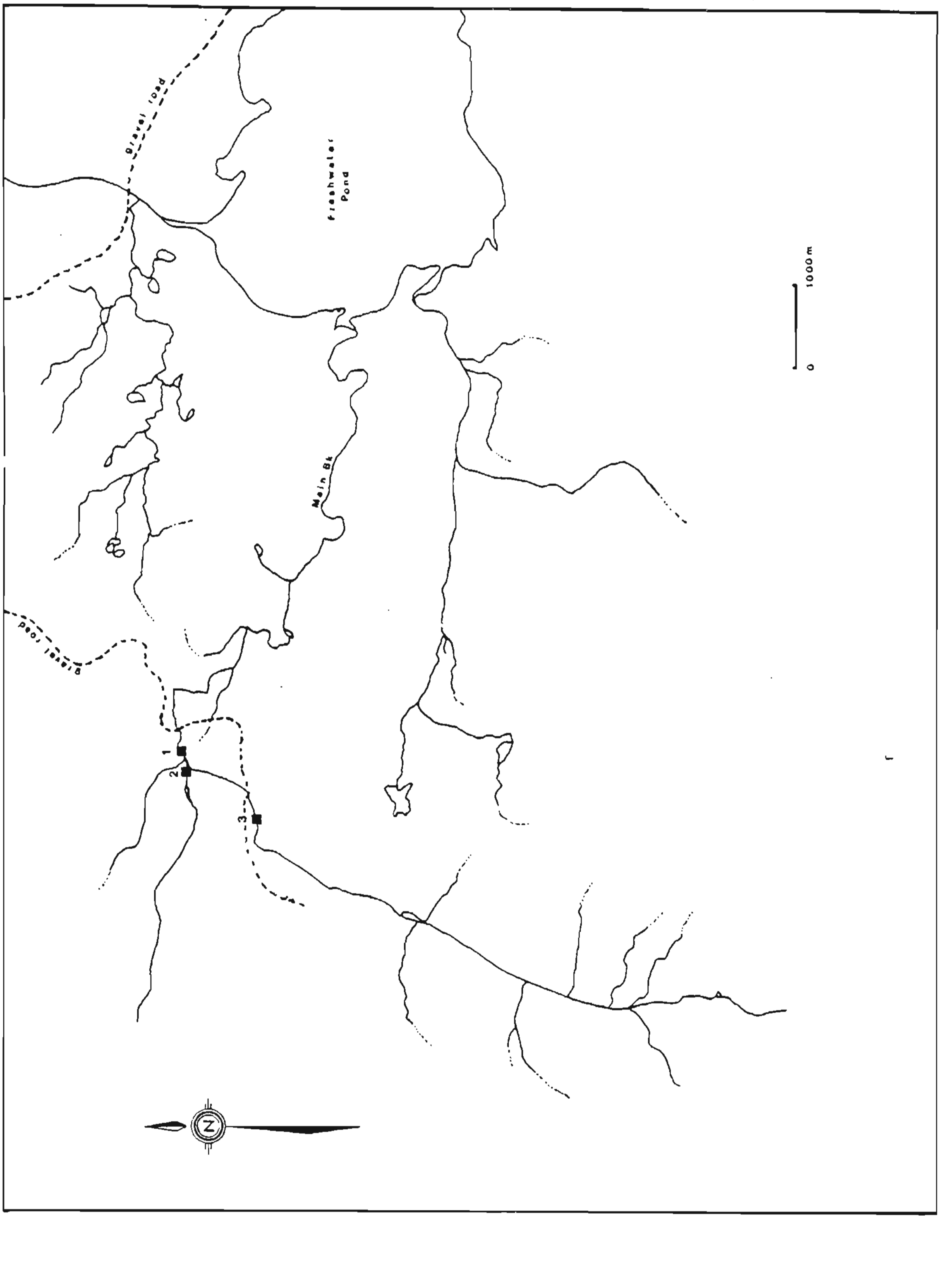

Fig. 6. Area 4 - Tides Brook stations.

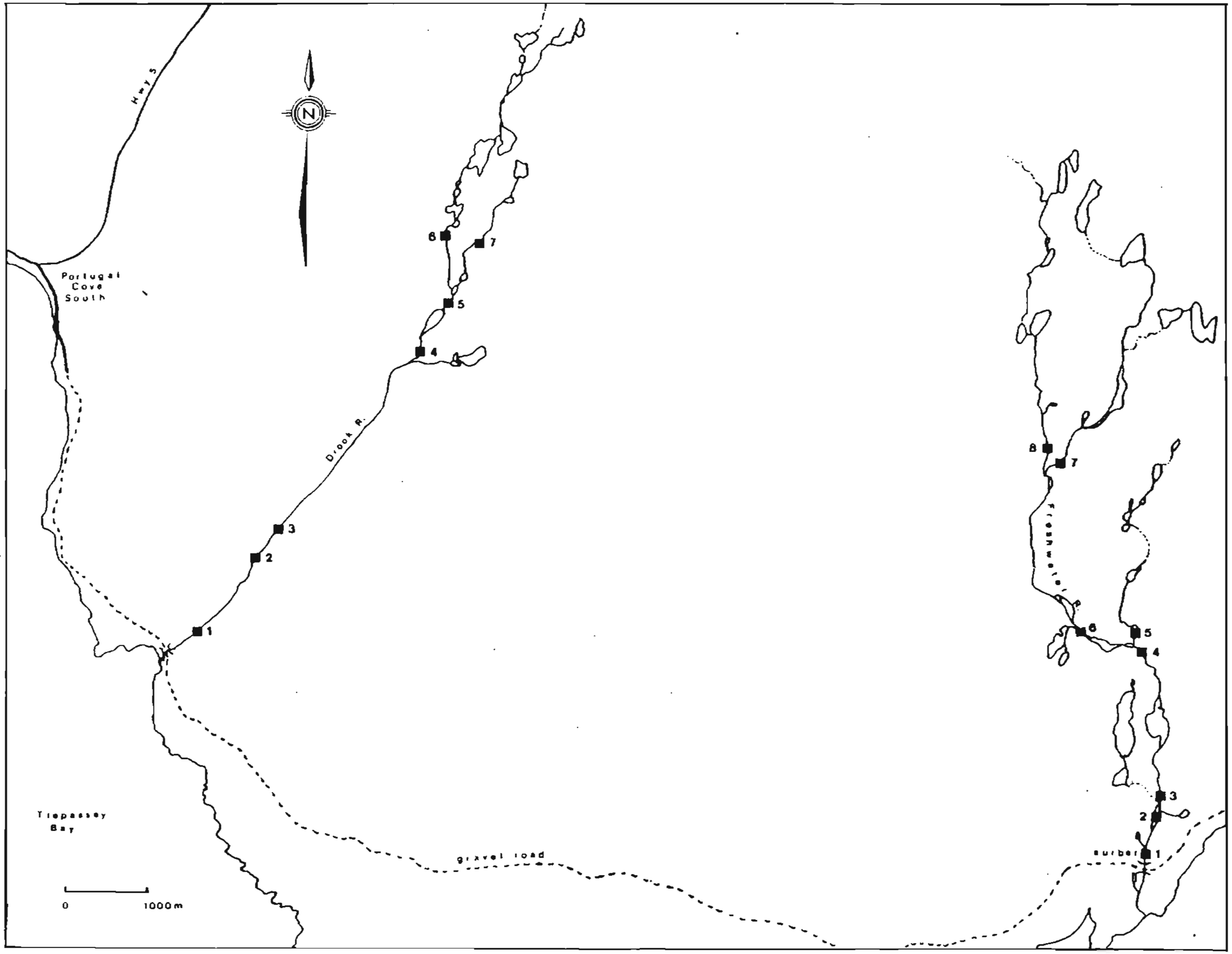

Fig. 7. Area 5 - Drook and Freshwater River stations.

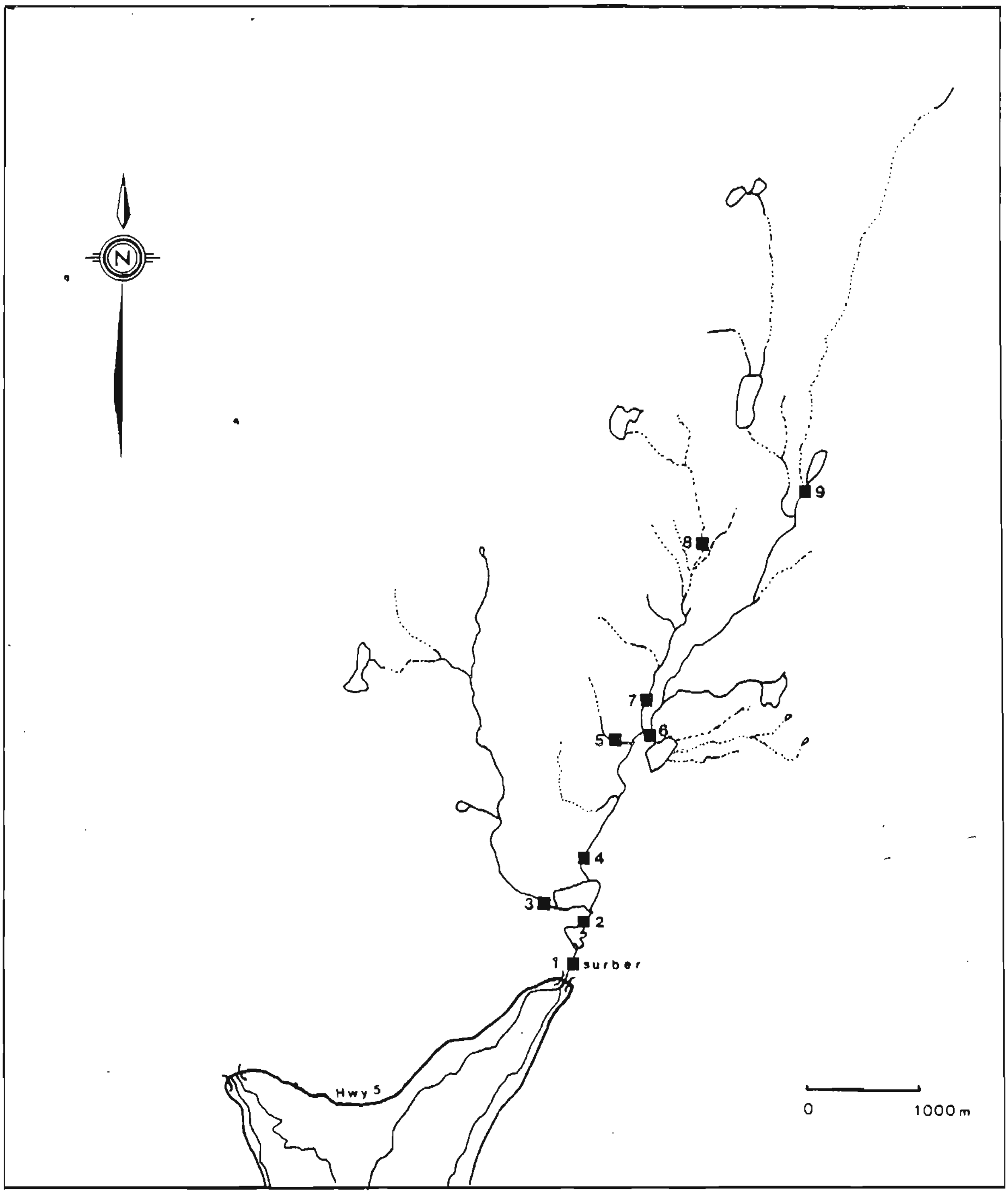

Fig. 8. Area 5 - Northeast Brook stations.

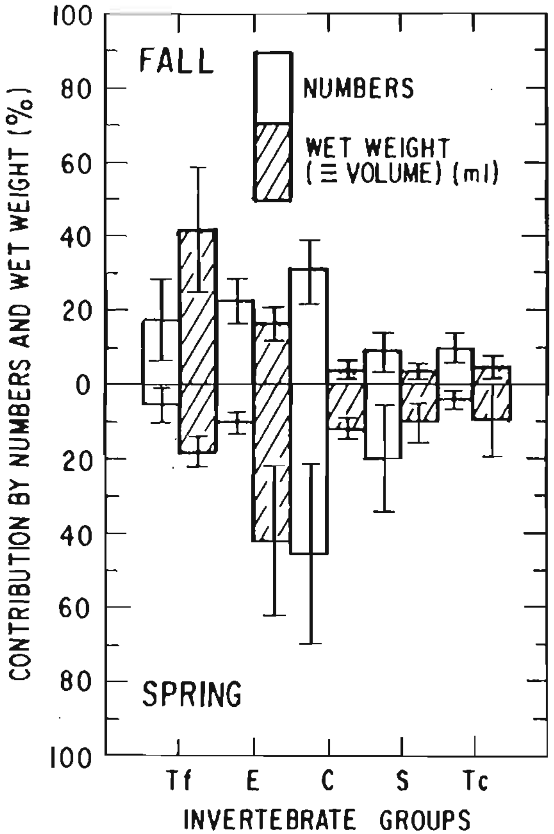

Fig. 9. Mean amounts per sampler of the most important invertebrate groups from all samples. Bars represent standard deviations either side of the mean.

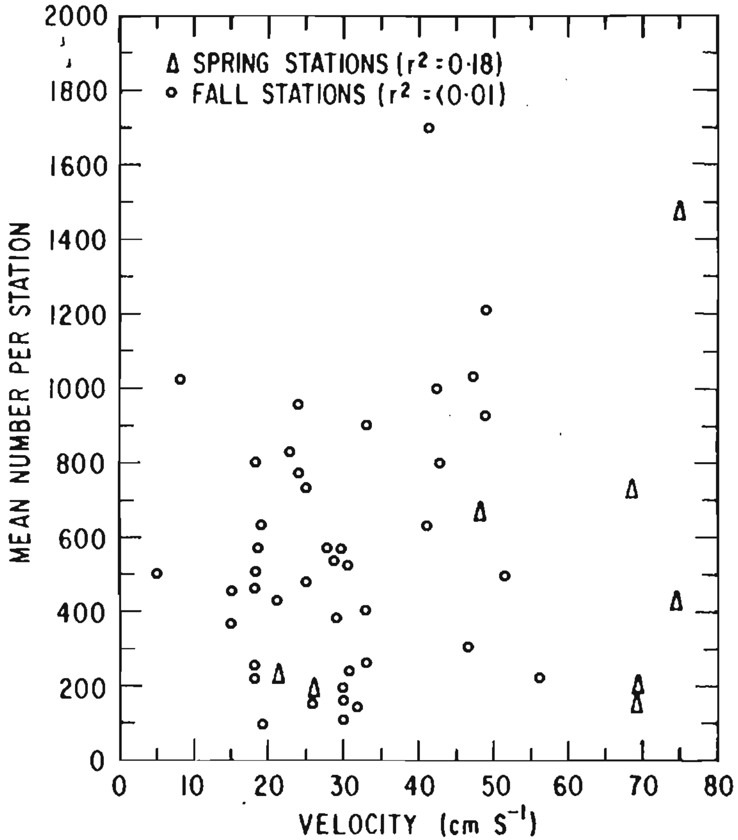

Fig. 10. Effect of velocity on mean number of aquatic invertebrates per station.

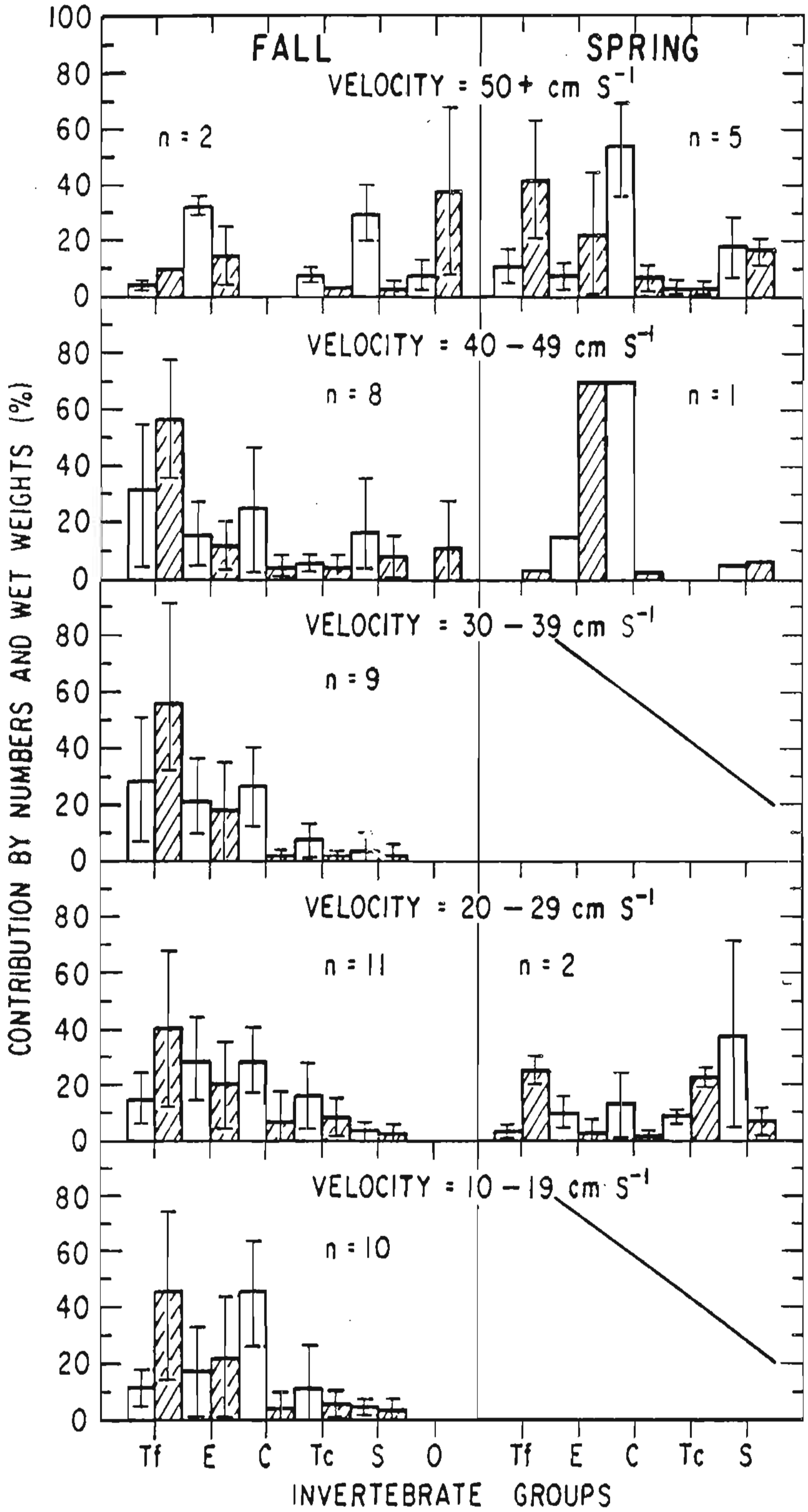

Fig. 11. Abundance of the predominant invertebrate groups relative to water velocity.

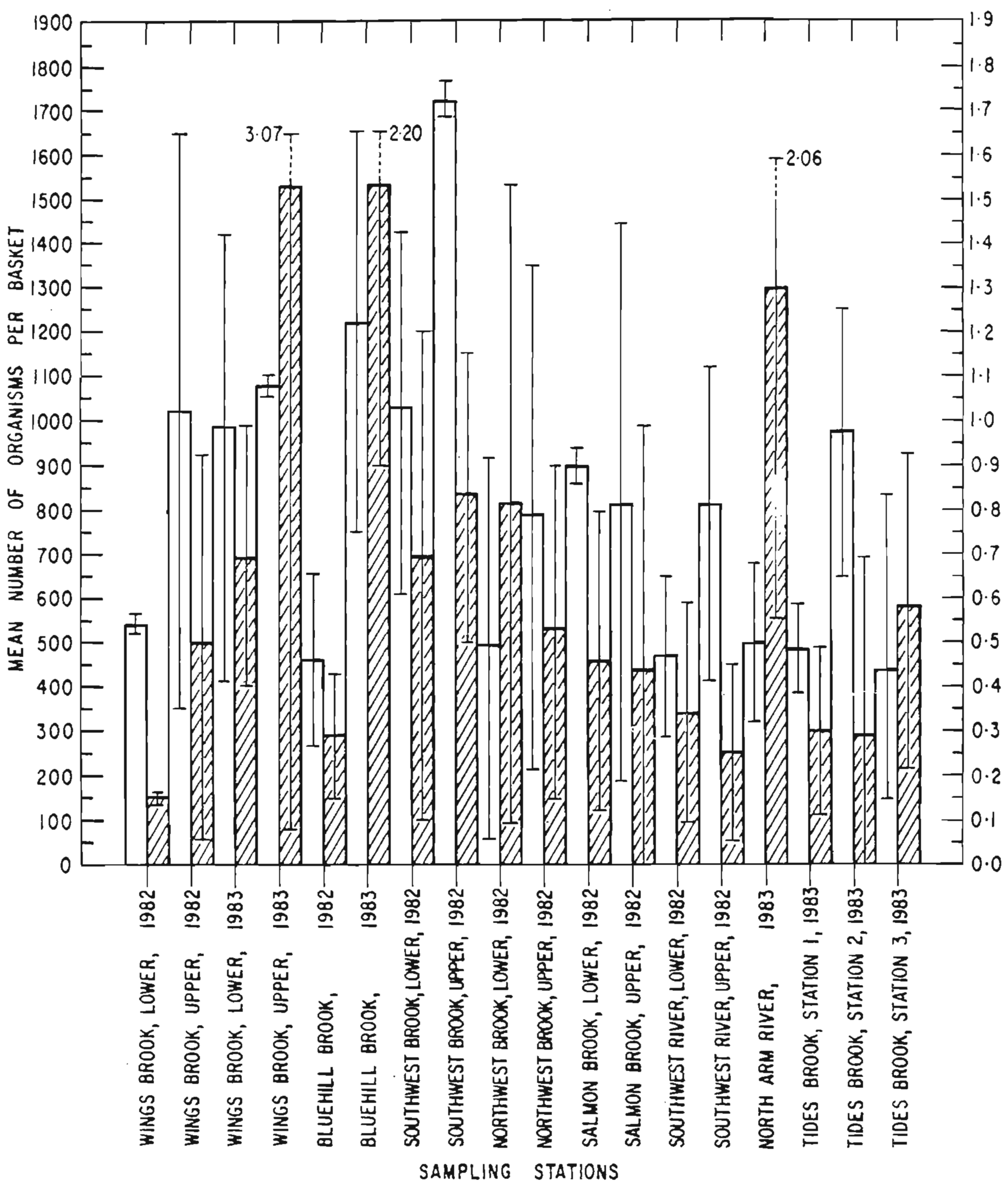

Fig. 12. The mean number and mean wet weight of collected organisms at stations in the fall of 1982 and 1983.

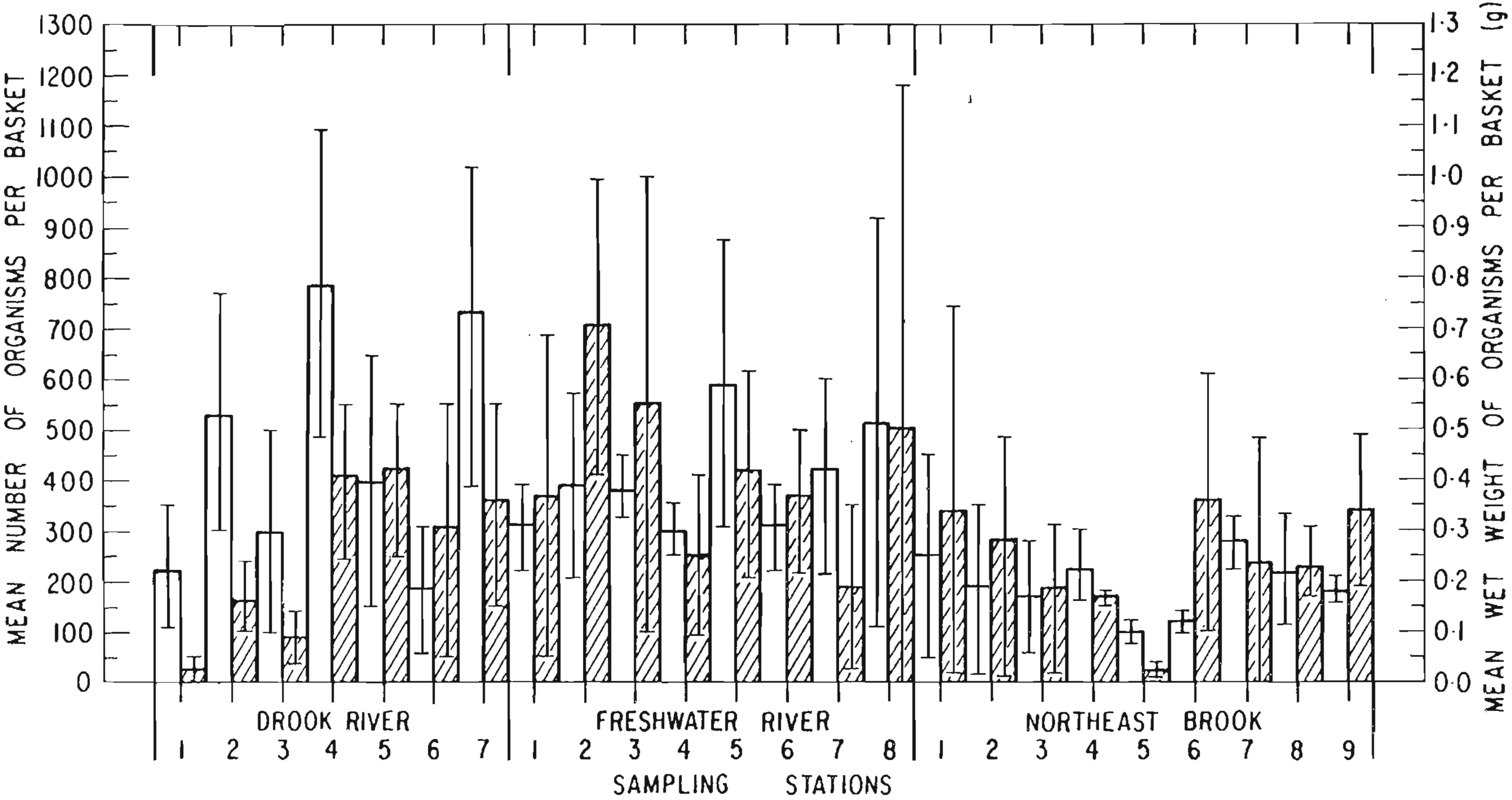

Fig. 13. The mean number and mean wet weight of collected organisms in area 5 in the fall of 1984.

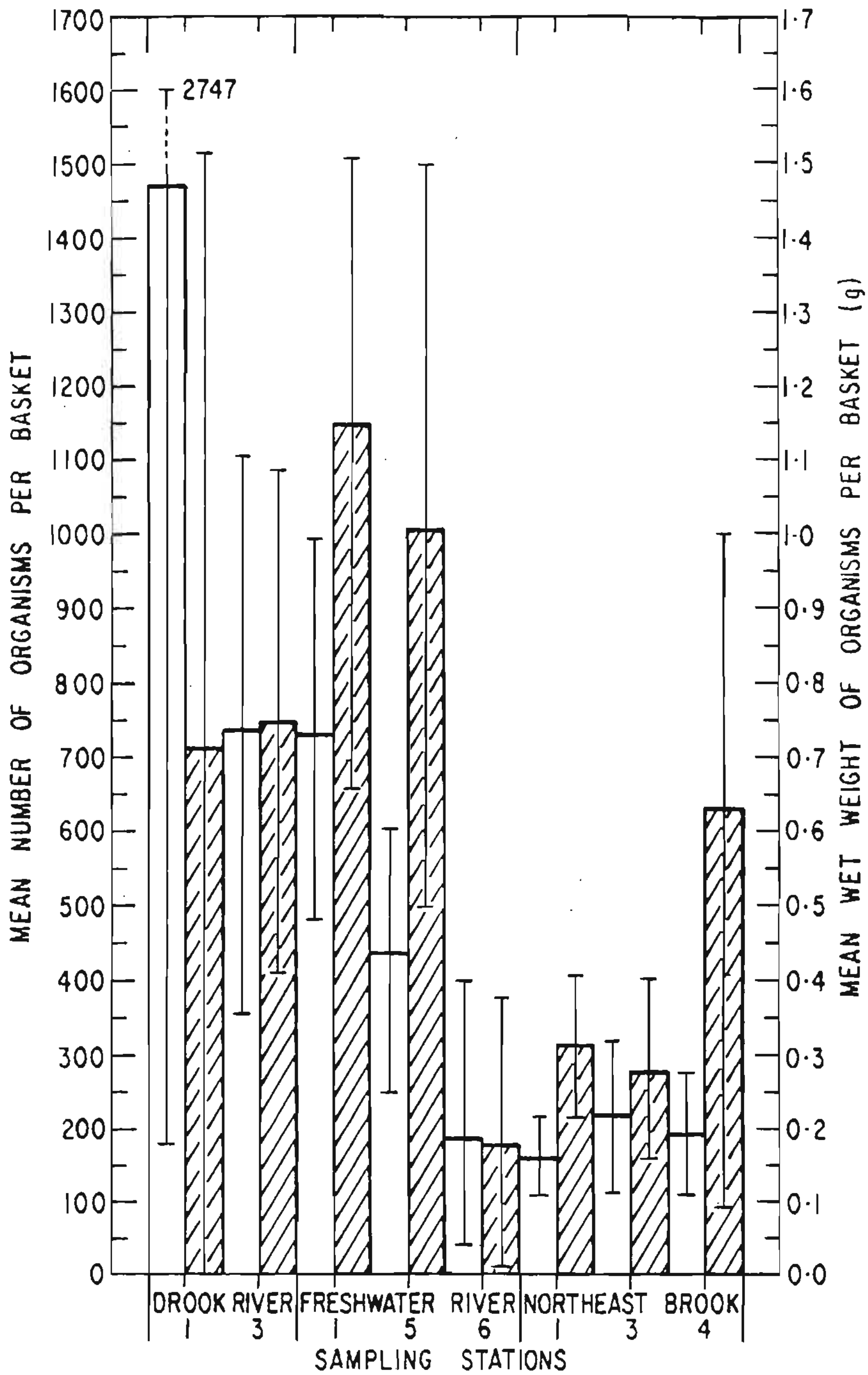

Fig. 14. The mean number and mean wet weight of collected organisms in area 5 in the spring of 1985.

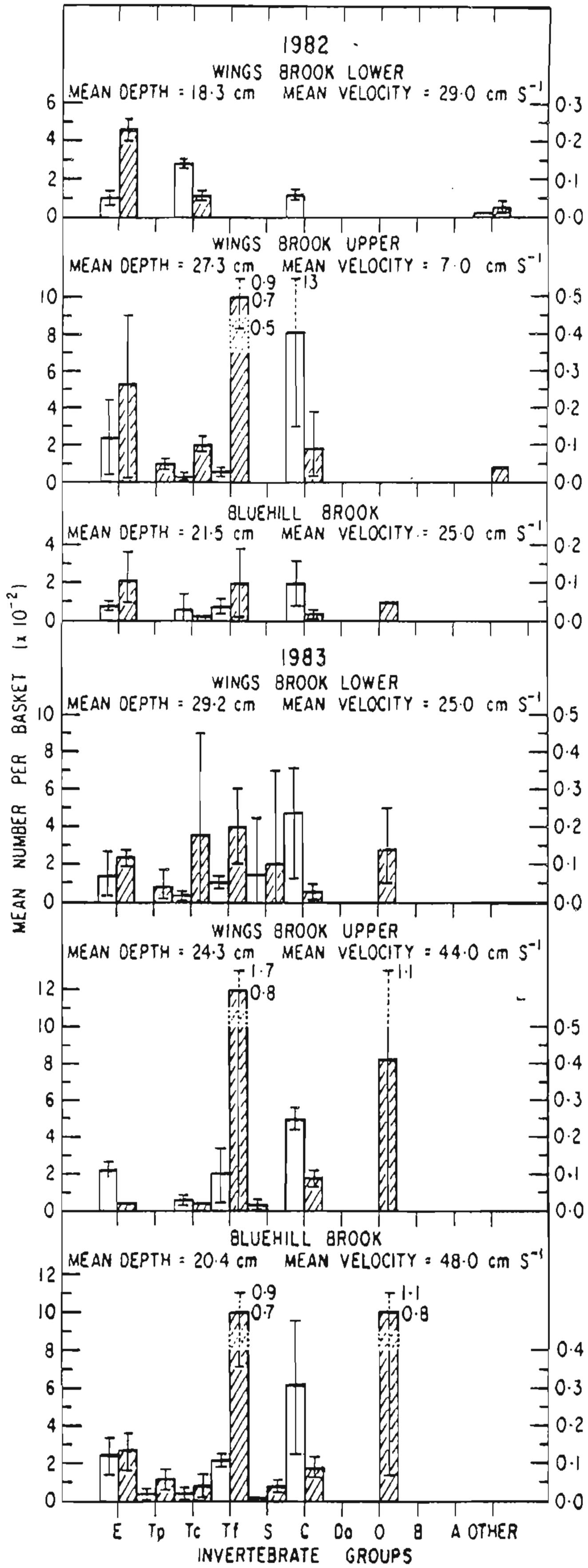

Fig. 15. The numerical and volumetric contributions of invertebrates collected from the Wings Brook system (area 1) in the fall.

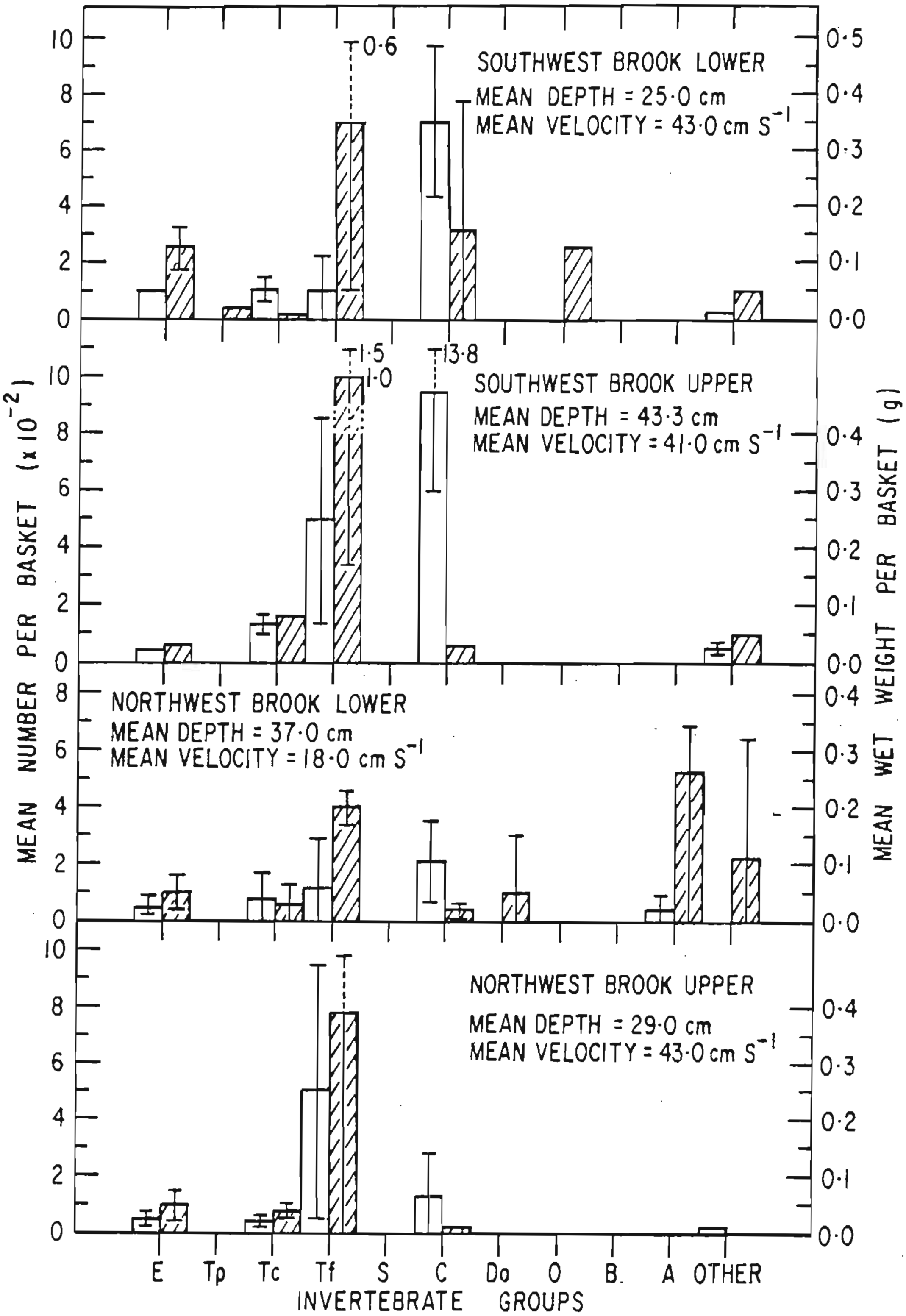

Fig. 16. The numerical and volumetric contributions of invertebrates collected from Southwest Brook and Northwest Brook (area 1) in the fall.

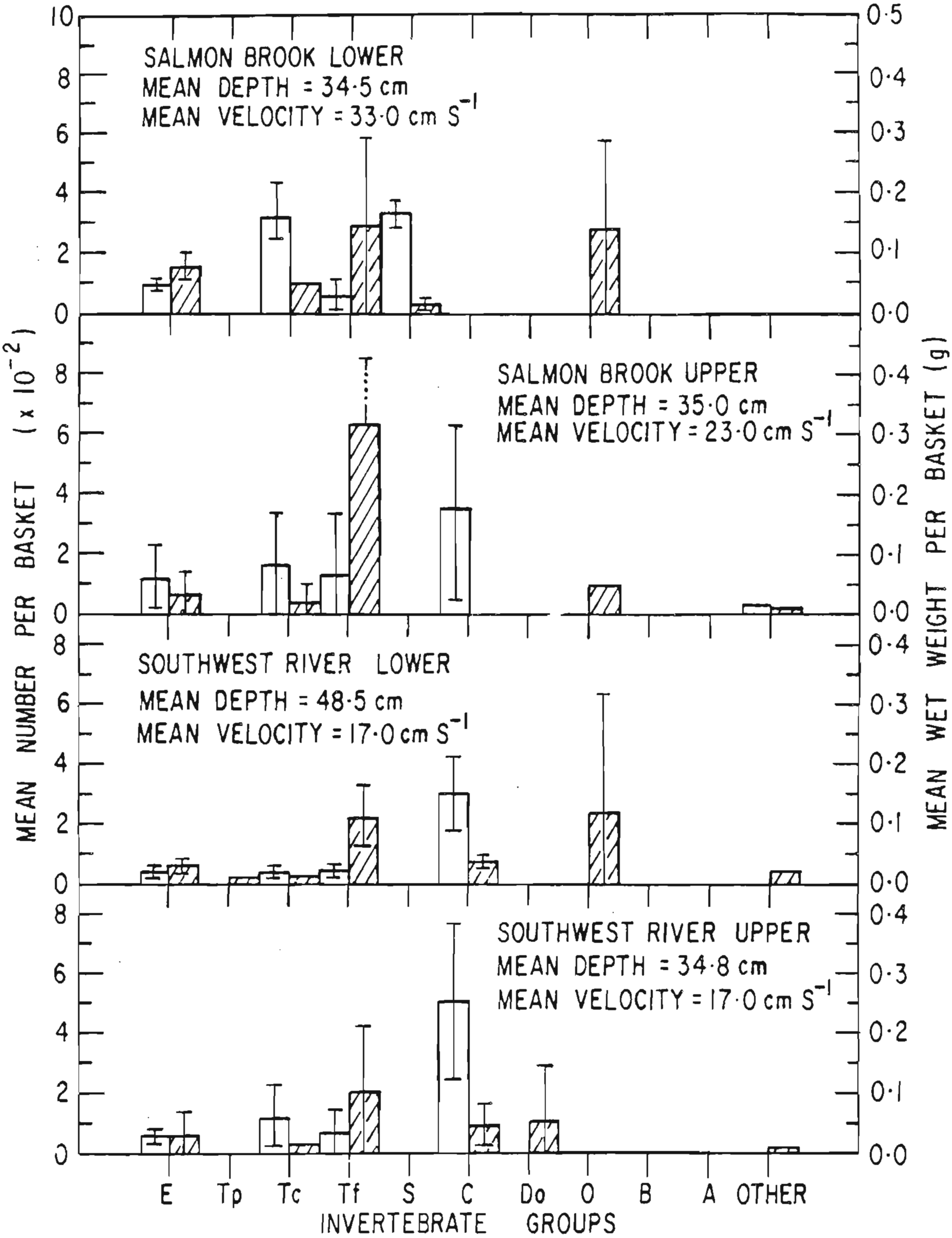

Fig. 17. The numerical and volumetric contributions of invertebrates collected from Salmon Brook and Southwest Brook (area 2) in the fall.

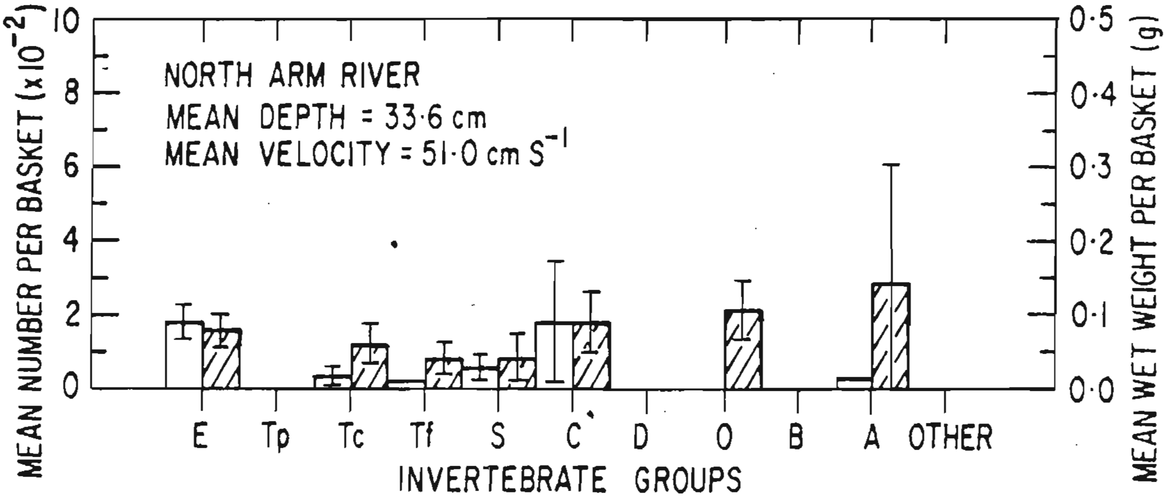

Fig. 18. The numerical and volumetric contributions of invertebrates collected from North Arm River (area 3) in the fall.

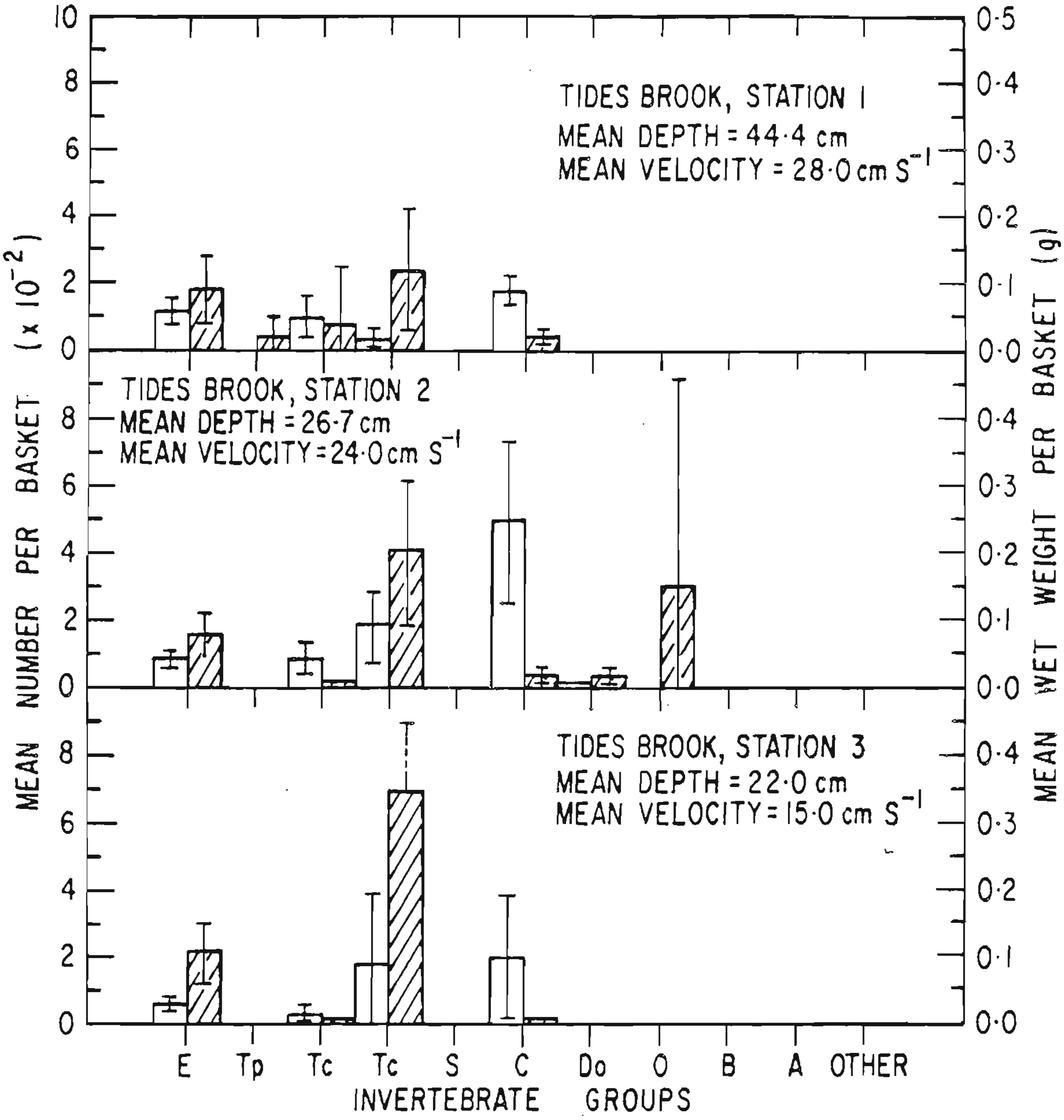

Fig. 19. The numerical and volumetric contributions of invertebrates collected from Tides Brook (area 4) in the fall.

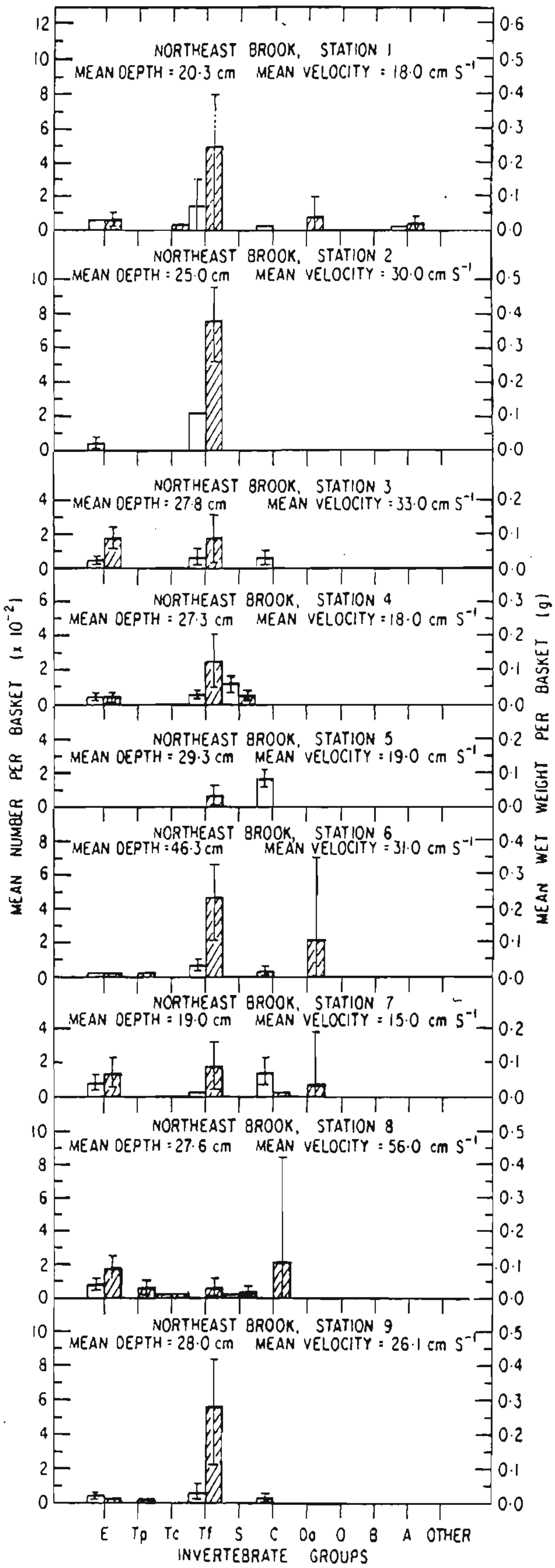

Fig. 20. The numerical and volumetric contributions of invertebrates collected from Northeast Brook (area 5) in the fall.

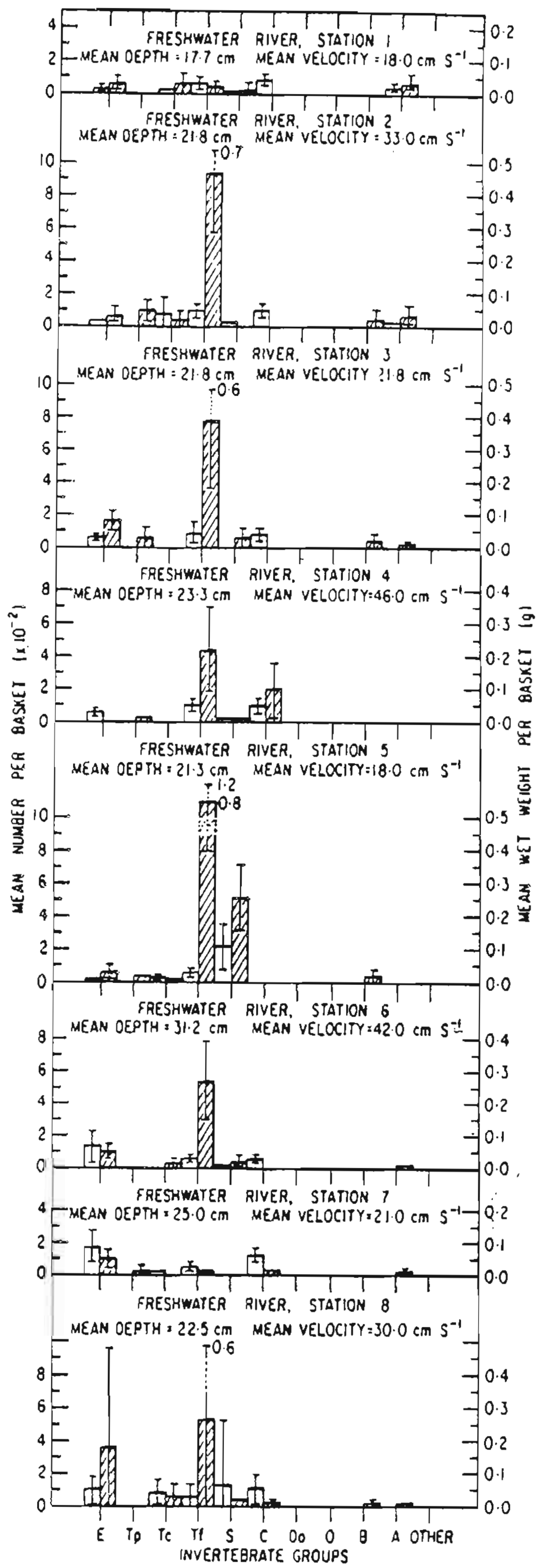

Fig. 21. The numerical and volumetric contributions of invertebrates collected from Freshwater River (area 5) in the fall.

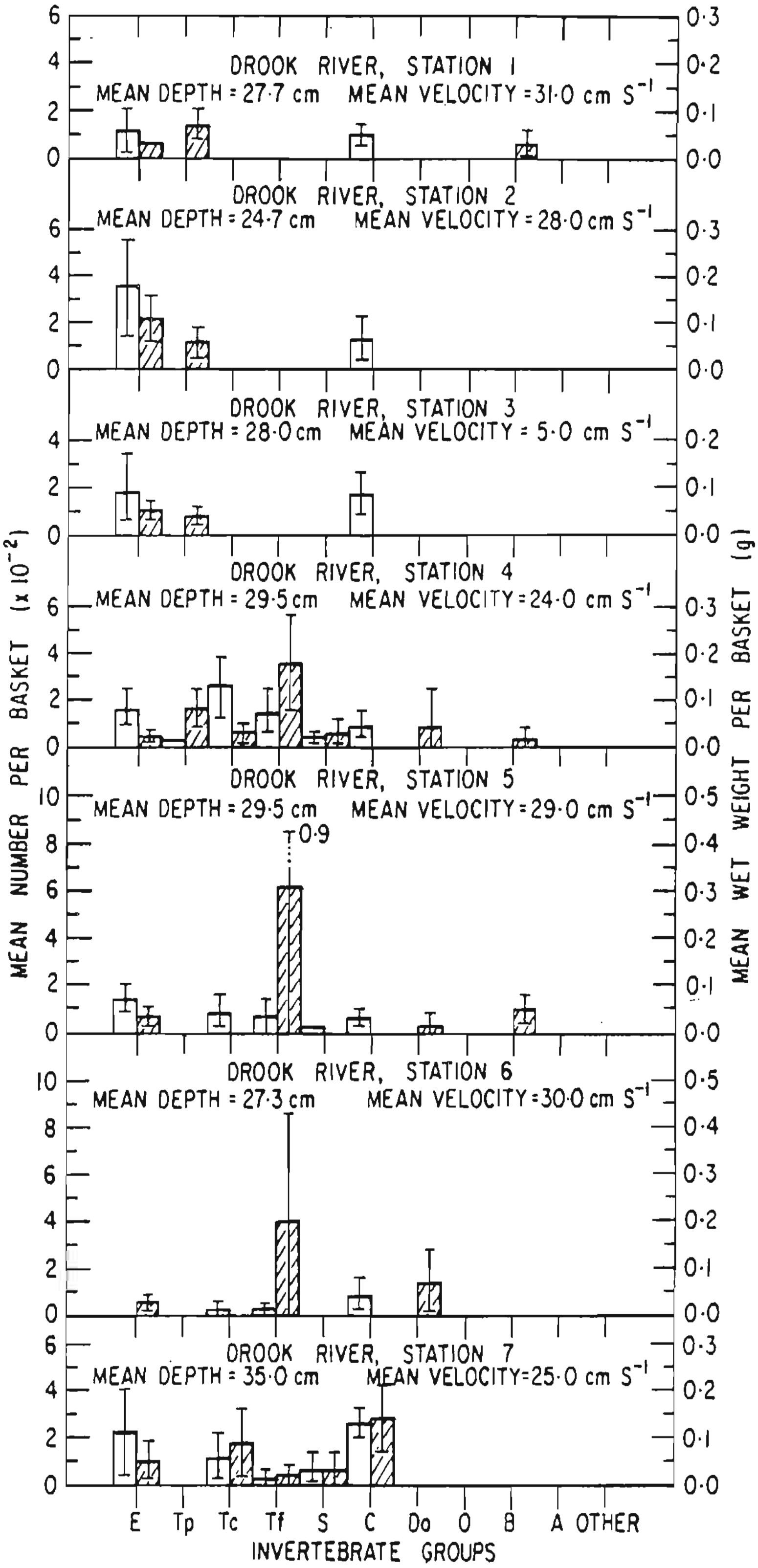

Fig. 22. The numerical and volumetric contributions of invertebrates collected from Drook River (area 5) in the fall.

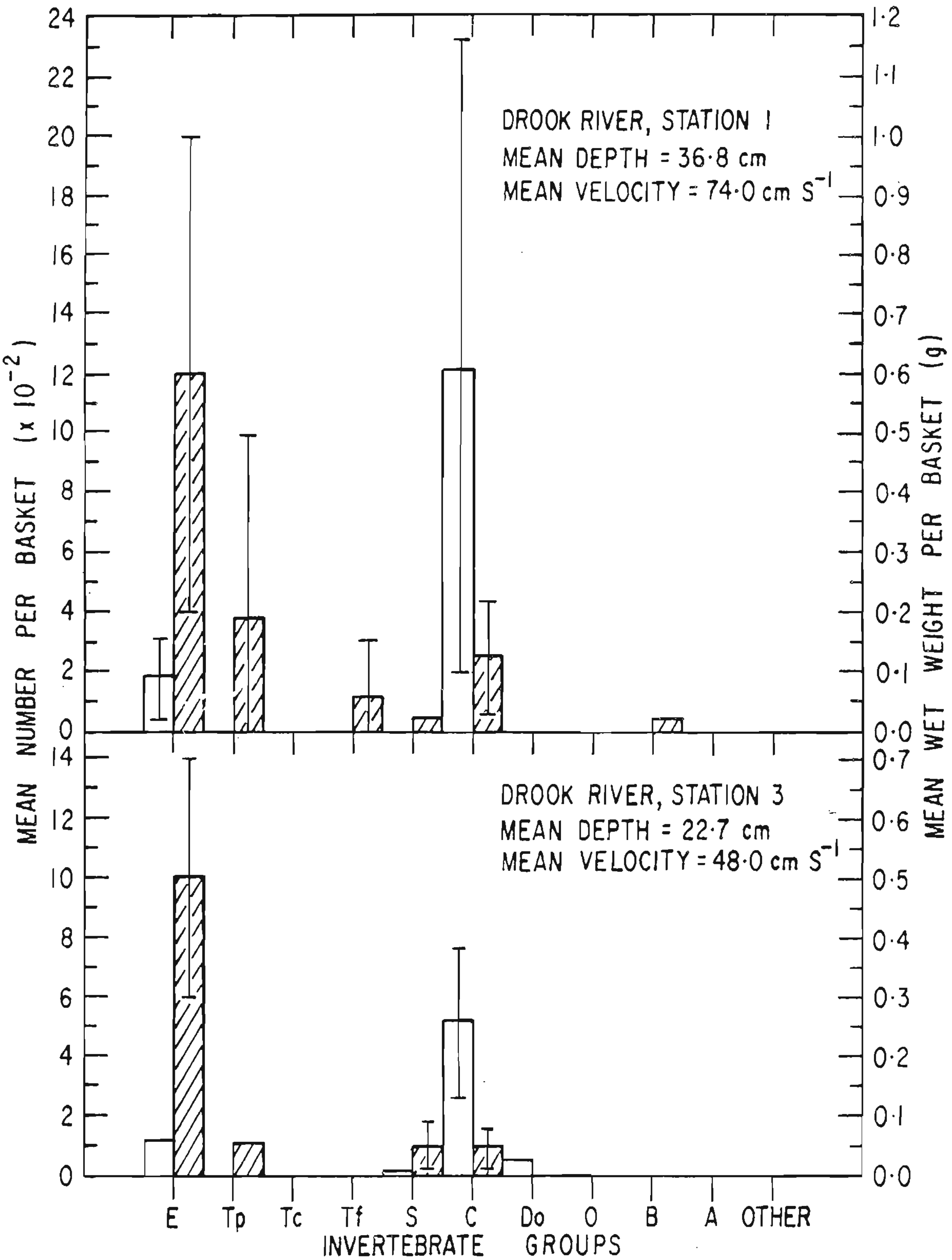

Fig. 23. The numerical and volumetric contributions of invertebrates collected from Drook River (area 5) in the spring.

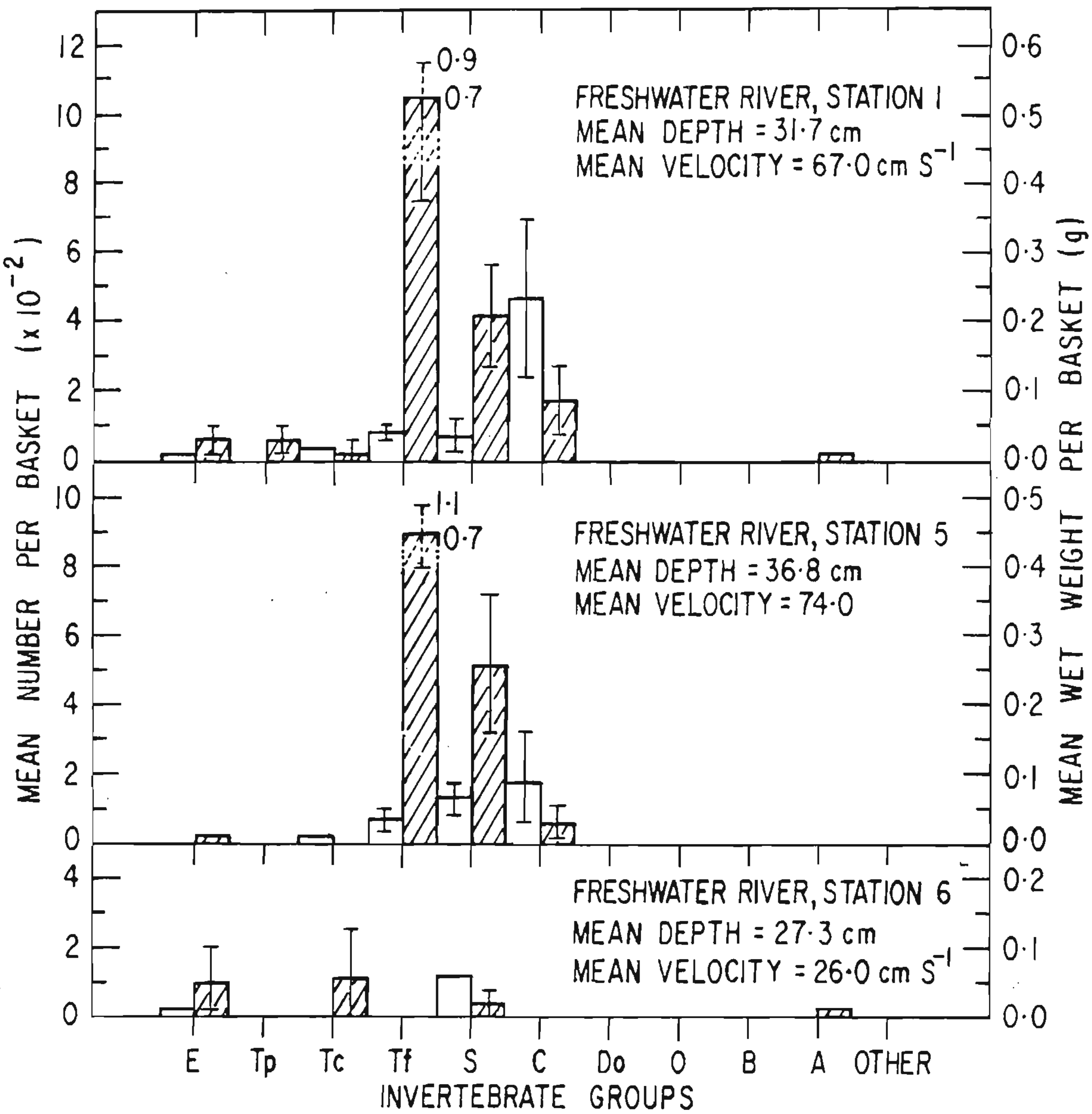

Fig. 24. The numerical and volumetric contributions of invertebrates collected from Freshwater River (area 5) in the spring.

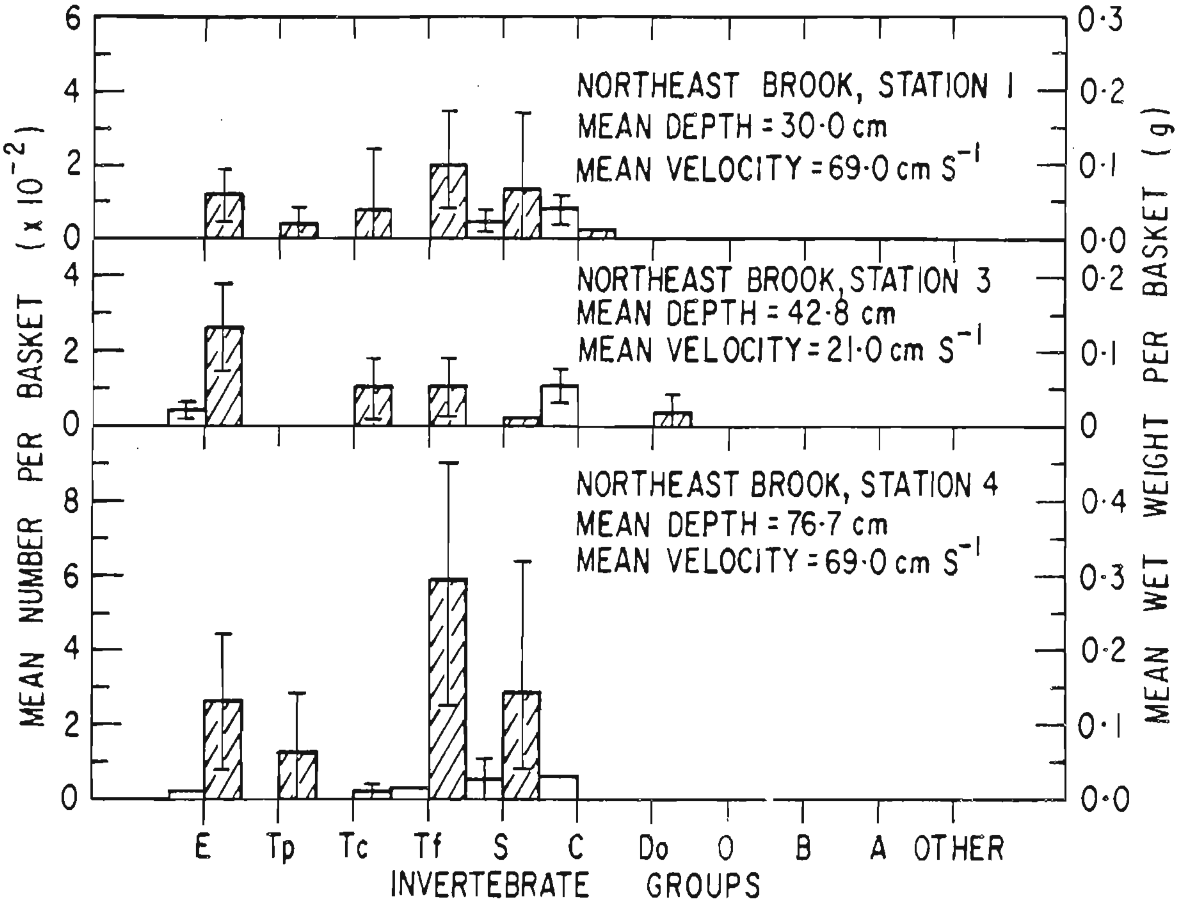

Fig. 25. The numerical and volumetric contributions of invertebrates collected from Northeast Brook (area 5) in the spring.

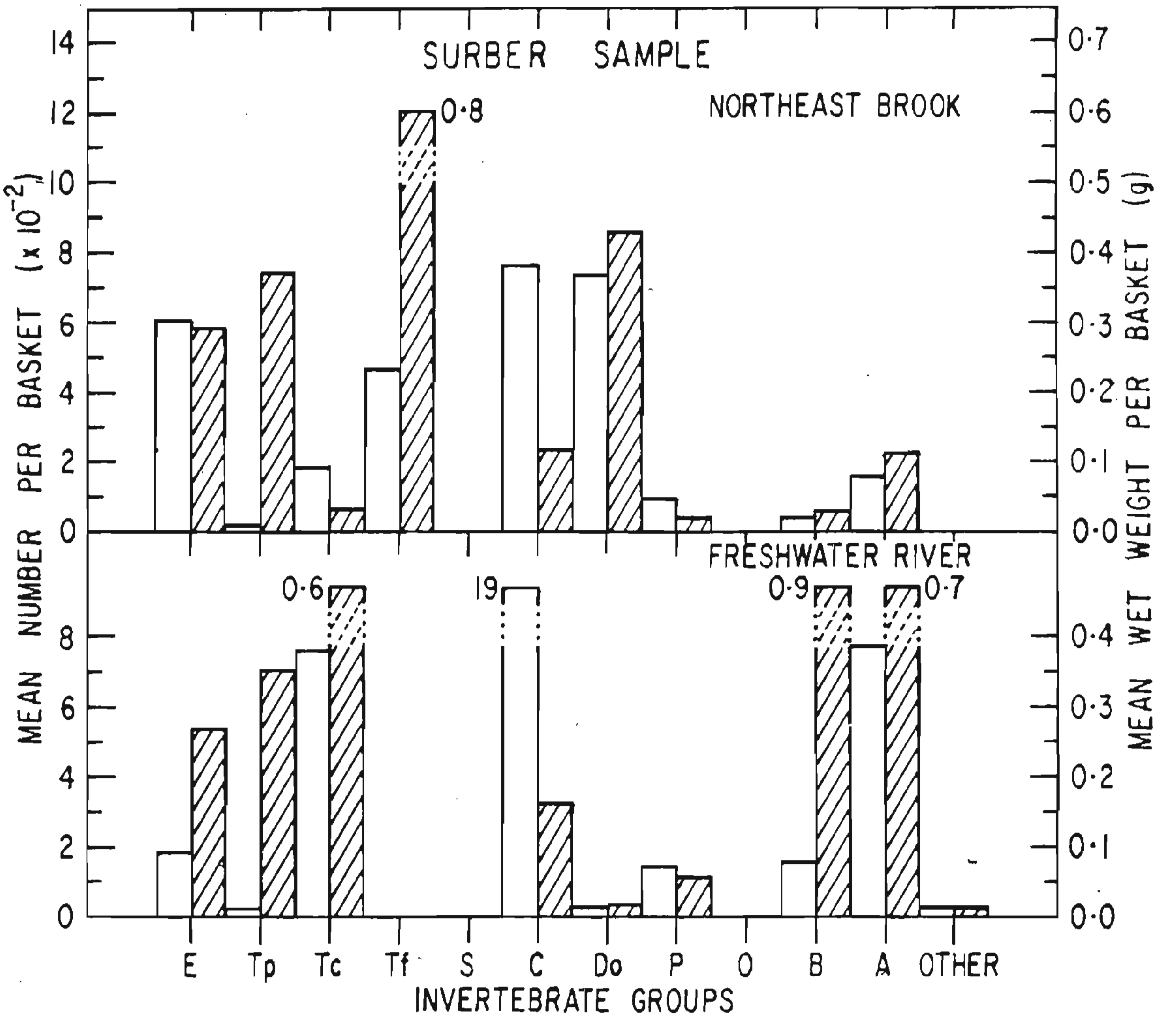

Fig. 26. The numerical and volumetric contributions of invertebrates collected by Surber sampler from Northeast Brook and Freshwater River (area 5) in the fall.

Appendix -- Invertebrate Samples Collected by Basket or Surber Samplers

River	Station	Sampling season	No. of samples*	Invertebrate groups (mean no. per sample as upper figure, mean wet weight in the lower figure)																		Total organisms per sample		
				E	Tp	Tc	Tf	S	C	Do	Ps	Pf	O	Co	B	H	A	G	P	Z	Oth	Mean no.	Mean wet wt	Mean dry wt
Wings Bk.	Upper	Fall/82	5	138.4 0.16	6.0 0.01	16.6 0.02	44.8 0.14	0.60 -	310.2 0.06	0.60 -	4.40 -	0.20 -	0.40 0.10	- -	- -	- -	- -	- -	- -	- -	3.40 0.02	1025	0.50	-
Wings Bk.	Lower	Fall/82	3	129.67 0.23	- -	276.33 0.06	4.67 -	0.33 -	112.33 0.01	1.00 -	7.33 -	0.67 -	- -	- -	- -	- -	- -	- -	- -	- -	10.33 -	543	0.15	-
Bluehill Bk.		Fall/82	5	106.4 -	4.0 -	52.8 0.01	75.8 0.10	0.80 -	204.6 0.02	- -	2.6 -	0.8 -	0.2 0.05	- -	- -	- -	- -	- -	- -	- -	16.6 0.05	464	0.29	-
Wings Bk.	Upper	Fall/83	5	221.8 0.18	1.0 -	63.0 0.02	204.6 0.79	43.80 0.08	5.00 0.08	9.80 -	17.60 -	0.80 -	5.40 0.42	0.20 -	0.40 -	- -	- -	- -	- -	- -	0.40 -	1072	1.57	0.148
Wings Bk.	Lower	Fall/83	6	143.5 0.13	10.17 0.05	31.0 0.01	95.0 0.21	152.0 0.12	450.17 0.03	3.33 -	3.50 0.002	0.83 -	0.67 0.13	1.50 -	0.17 -	3.50 -	- -	- -	- -	- -	0.33 -	924	0.68	0.065
Bluehill Bk.		Fall/83	5	230.6 0.13	37.8 0.06	42.6 0.01	227.2 0.77	27.0 0.04	613.6 0.09	3.40 -	6.40 0.01	12.6	4.40 0.76	1.80 -	- -	0.06 -	0.40 -	- -	- -	- -	- -	1208	1.56	0.169
Southwest Bk.	Upper	Fall/82	3	33.3 -	2.33 -	145.33 0.08	508.0 0.62	- -	990.33 0.03	- -	8.33 -	3.33 -	0.33 -	- -	- -	- -	- -	- -	- -	- -	33.0 -	1724	0.83	-
Southwest Bk.	Lower	Fall/82	4	102.75 0.13	2.50 0.03	56.25 0.01	116.25 0.36	1.00 -	712.75 0.17	- -	18.50 -	- -	0.25 -	- -	- -	- -	- -	- -	- -	- -	21.25 0.14	1032	0.69	-
Northwest Bk.	Upper	Fall/82	4	43.75 0.08	3.50 -	33.25 0.05	509.25 0.40	0.75 -	176.75 0.01	- -	3.50 -	- -	- -	- -	- -	- -	- -	- -	- -	- -	18.75 -	790	0.53	-
Northwest Bk.	Lower	Fall/82	6	45.17 0.05	0.67 -	69.33 0.02	118.33 0.21	1.33 -	219.17 -	3.00 0.05	2.83 -	0.67 -	- -	- -	- -	- -	28.50 0.30	- -	- -	- -	10.0 0.16	499	0.83	-
Salmon R.	Upper	Fall/82	5	124.4 0.03	1.0 -	163.4 0.03	139.20 0.32	1.20 -	351.80 0.01	- -	7.80 0.01	- -	0.20 -	- -	- -	- -	- -	- -	- -	- -	23.80 0.06	813	0.44	-
Salmon R.	Lower	Fall/82	2	105.5 0.08	- -	330.5 0.05	85.50 0.15	4.50 -	351.0 0.04	- -	5.50 -	- -	0.50 -	- -	- -	- -	- -	- -	- -	- -	16.50 0.15	900	0.46	-
Southwest R.	Upper	Fall/82	4	59.0 0.03	3.75 -	133.0 0.01	61.50 0.11	0.25 -	503.25 0.04	5.75 0.05	11.0 -	- -	- -	- -	- -	- -	- -	- -	- -	- -	10.25 0.01	788	0.25	-
Southwest R.	Lower	Fall/82	4	39.0 0.06	1.75 0.01	45.0 0.01	69.75 0.12	0.50 -	308.0 0.02	- -	4.50 -	- -	3.50 0.13	- -	- -	- -	- -	- -	- -	- -	10.50 -	472	0.34	-

River	Station	Sampling season	No. of samples*	Invertebrate groups (mean no. per sample as upper figure, mean wet weight in the lower figure) E	Tp	Tc	Tf	S	C	Do	Ps	Pf	O	Co	B	H	A	G	P	Z	Oth	Total organisms per sample Mean no.	Mean wet wt	Mean dry wt
North Arm R.		Fall/83	5	144.6	1.40	32.80	20.80	58.40	207.80	2.60	3.80	-	7.0	5.40	12.80	-	0.60	0.20	-	-	-	500	1.30	0.087
				0.06	0.002	0.04	0.03	0.04	-	-	-	-	0.93	-	0.11	-	-	-	-	-	-			
Tides Bk.	1	Fall/83	6	104.17	1.17	88.33	27.17	0.67	153.17	2.67	20.0	0.33	-	1.00	2.33	3.50	0.17	0.33	-	-	0.17	487	0.30	0.030
				0.08	0.02	0.04	0.10	-	0.01	-	-	-	-	0.002	0.01	-	0.33	0.002	-	-	-			
Tides Bk.	2	Fall/83	5	108.60	3.60	115.60	233.80	3.80	602.20	25.60	15.80	1.60	0.20	8.40	3.80	24.80	-	0.60	-	-	-	957	0.29	0.035
				0.09	0.04	0.04	0.03	-	0.02	-	0.03	-	0.18	-	-	-	-	0.002	-	-	-			
Tides Bk.	3	Fall/83	6	59.67	1.0	30.50	94.17	1.50	202.5	1.17	45.33	0.17	-	1.17	0.67	1.33	-	-	-	-	-	439	0.58	0.054
				0.11	0.01	0.03	0.35	0.002	0.01	-	0.07	-	-	-	0.002	-	-	-	-	-	-			
Northeast Bk.	1	Fall/84	6	54.67	2.00	8.0	144.17	1.17	15.83	0.50	2.50	0.67	-	1.67	-	2.17	17.67	0.83	-	-	0.17	252	0.34	0.046
				0.03	0.01	0.01	0.25	-	-	0.04	-	-	-	-	-	-	0.02	-	-	-	-			
Northeast Bk.	2	Fall/84	5	25.40	1.00	5.00	128.00	-	9.20	0.20	5.00	0.80	-	1.60	0.60	0.80	8.00	-	-	0.20	-	186	0.28	0.052
				0.02	-	-	0.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	3	Fall/84	4	46.50	1.75	13.00	73.50	-	23.75	0.50	-	2.50	-	2.50	0.50	0.25	-	0.25	-	-	-	165	0.18	0.025
				0.09	0.002	-	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	4	Fall/84	6	37.33	3.83	12.33	42.17	0.50	126.83	0.33	0.67	-	-	0.33	0.17	2.67	0.33	-	-	-	0.33	228	0.17	0.035
				0.01	-	0.01	0.13	-	0.003	0.01	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	5	Fall/84	6	3.33	1.33	1.83	5.17	0.50	86.83	-	-	0.17	-	0.50	0.17	0.33	0.83	-	-	-	0.33	103	0.03	0.005
				-	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	6	Fall/84	6	14.83	3.00	7.33	50.0	2.33	37.33	1.0	-	2.33	-	2.00	-	0.17	0.33	-	-	-	-	121	0.36	0.060
				0.01	0.01	0.002	0.24	-	0.002	0.11	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	7	Fall/84	6	64.67	9.33	10.33	25.83	2.17	148.50	0.33	0.17	4.83	-	3.83	0.83	0.83	3.67	-	-	-	0.33	276	0.24	0.035
				0.07	0.01	0.01	0.09	-	0.01	0.06	-	-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	8	Fall/84	5	77.60	13.00	19.20	10.40	28.20	57.20	2.20	-	2.00	-	12.00	0.60	1.20	0.20	-	-	-	0.80	225	0.25	0.030
				0.08	0.03	0.01	0.03	-	-	0.16		-	-	-	-	-	-	-	-	-	-			
Northeast Bk.	9	Fall/84	6	40.67	0.33	12.33	63.67	3.17	37.17	-	8.33	-	-	2.00	0.17	0.83	0.17	-	-	-	1.17	171	0.34	0.050
				0.03	-	0.03	0.27	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-			
Freshwater R.	1	Fall/84	6	43.67	2.83	24.67	53.83	22.83	97.67	1.00	0.17	1.50	-	5.00	2.50	0.50	42.00	9.33	-	-	-	308	0.37	0.052
				0.03	0.003	0.03	0.23	0.01	0.002	-	-	-	-	-	-	-	0.06	0.01	-	-	-			

River	Station	Sampling season	No. of samples*	Invertebrate groups (mean no. per sample as upper figure, mean wet weight in the lower figure) E	Tp	Tc	Tf	S	C	Do	Ps	Pf	O	Co	B	H	A	G	P	Z	Oth	Total organisms per sample Mean no.	Mean wet wt	Mean dry wt
Freshwater R.	2	Fall/84	6	29.17 0.06	3.67 0.05	76.33 0.02	111.0 0.51	19.0 0.002	108.83 0.003	- -	- -	1.50 -	- -	5.17 -	3.83 0.02	2.67 -	25.50 0.03	10.33 0.04	- -	- -	0.17 -	397	0.72	0.099
Freshwater R.	3	Fall/84	6	66.67 0.08	2.50 0.03	7.50 -	87.83 0.40	17.50 0.03	75.83 -	- -	- -	1.33 -	- -	2.33 -	6.17 0.02	1.33 -	8.00 0.01	- -	4.17 0.01	- -	- -	281	0.56	0.075
Freshwater R.	4	Fall/84	6	49.0 0.003	1.83 0.01	7.67 -	102.83 0.22	23.00 0.01	106.17 0.003	0.50 -	- -	1.50 -	- -	3.33 -	1.33 0.01	0.83 -	1.67 -	0.17 -	- -	- -	- -	300	0.25	0.044
Freshwater R.	5	Fall/84	6	19.50 0.03	3.17 0.02	35.00 0.01	96.67 0.25	222.17 0.11	206.67 -	0.33 0.002	- -	0.33 -	- -	2.33 -	4.17 0.02	0.67 -	3.50 -	- -	- -	- -	0.17 -	595	0.42	0.052
Freshwater R.	6	Fall/84	6	130.33 0.05	0.50 0.002	10.00 0.01	69.83 0.27	21.50 0.02	61.33 0.002	0.50 -	- -	- -	- -	8.33 -	0.67 -	1.33 -	11.83 0.01	- -	- -	- -	0.33 -	317	0.37	0.048
Freshwater R.	7	Fall/84	6	185.00 0.05	5.67 0.01	19.50 -	56.83 0.10	6.33 -	124.00 0.01	0.33 -	0.17 -	1.67 -	- -	4.67 -	3.50 0.01	4.50 -	13.83 0.01	- -	- -	- -	0.17 -	426	0.19	0.042
Freshwater R.	8	Fall/84	6	118.67 0.16	3.17 -	79.83 0.03	54.67 0.27	120.83 0.04	106.50 0.01	0.50 -	- -	- -	- -	7.00 -	2.83 0.01	3.17 -	14.00 0.01	- -	- -	- -	0.33 -	512	0.51	0.074
Drook R.	1	Fall/84	6	120.83 0.03	- -	5.83 -	1.50 0.002	0.50 -	92.83 0.002	0.17 -	- -	0.17 -	- -	2.00 -	5.67 0.02	6.17 -	- -	- -	- -	- -	0.33 -	236	0.05	0.018
Drook R.	2	Fall/84	6	357.50 0.11	- -	13.33 0.06	1.17 -	5.67 -	6.17 -	140.50 -	0.50 -	1.17 -	0.33 -	2.17 -	0.17 -	6.00 -	- -	- -	- -	- -	0.50 -	535	0.17	0.026
Drook R.	3	Fall/84	6	193.17 0.05	8.00 0.04	1.50 -	0.17 -	2.67 -	89.00 -	- -	0.67 -	0.33 -	- -	0.33 -	1.33 -	2.33 -	- -	- -	- -	- -	2.17 -	300	0.08	0.015
Drook R.	4	Fall/84	6	174.83 0.04	30.67 0.08	256.83 0.03	151.83 0.18	43.50 0.03	93.67 -	2.17 0.03	- -	- -	- -	10.67 0.002	6.33 0.02	6.83 -	7.83 0.01	3.00 -	- -	0.50 -	0.33 -	789	0.41	0.073
Drook R.	5	Fall/84	6	132.33 0.03	2.17 0.002	100.00 0.01	68.33 0.31	33.50 0.01	53.50 -	2.33 0.01	- -	0.83 -	- -	2.33 -	11.67 0.05	6.00 -	2.33 0.01	- -	- -	- -	0.17 -	398	0.43	0.075
Drook R.	6	Fall/84	6	14.67 0.02	1.00 -	25.50 0.002	19.00 0.21	5.33 -	86.17 -	3.00 0.07	- -	2.00 -	- -	12.33 -	1.83 0.01	11.67 -	- -	- -	- -	- -	0.33 -	183	0.31	0.061
Drook R.	7	Fall/84	6	219.67 0.05	0.67 0.01	114.67 0.09	21.50 0.02	52.00 0.06	246.67 0.14	2.00 -	- -	0.83 -	- -	3.67 -	1.33 -	41.83 -	- -	- -	4.33 -	22.00 -	- -	731	0.36	0.031

River	Station	Sampling season	No. of samples*	Invertebrate groups (mean no. per sample as upper figure, mean wet weight in the lower figure) E	Tp	Tc	Tf	S	C	Do	Ps	Pf	O	Co	B	H	A	G	P	Z	Oth	Total organisms per sample Mean no.	Mean wet wt	Mean dry wt
Northeast R. (Surber sampler)		Fall/84	10**	603.0 0.30	17.0 0.37	196.0 0.06	468.0 0.85	- -	760.0 0.13	734.0 0.43	99.0 0.03		- -	108.0 0.05	37.0 0.03	20.0 -	175.0 0.12	2.0 0.01	- -	- -	- -	471	0.41	-
Freshwater R. (Surber sampler)		Fall/84	10**	194.0 0.27	18.0 0.35	754.0 0.59	- -	- -	1897.0 0.17	39.0 0.03	165.0 0.06		- -	284.0 0.11	170.0 0.93	32.0 0.05	782.0 0.74	187.0 0.29	- -	- -	30.0 0.01	352	0.35	-
Drook R.	1	Spring/85	6	194.33 0.46	- -	6.00 0.003	7.33 0.06	14.33 0.04	1211.83 0.13	20.67 -	0.33 -	2.83 0.002	- -	3.67 0.002	2.83 0.04	3.33 -	- -	- -	- -	- -	- -	1466	0.72	0.087
Drook R.	3	Spring/85	3	138.67 0.53	5.00 0.07	1.33 -	1.00 0.02	20.67 0.05	523.33 0.05	45.00 -	4.67 0.03	1.33 -	- -	1.33 -	0.33 -	1.33 -	- -	- -	- -	- -	- -	744	0.75	0.089
Freshwater R.	1	Spring/85	6	30.50 0.06	1.83 0.06	38.17 0.02	82.83 0.67	76.50 0.23	472.00 0.09	3.50 -	- -	0.33 -	- -	10.17 0.003	1.00 0.02	2.17 -	11.33 0.01	0.50 -	- -	- -	- -	731	1.15	0.128
Freshwater R.	5	Spring/85	6	1.17 0.01	0.33 0.01	17.67 -	73.67 0.77	144.50 0.26	189.33 0.03	- -	- -	3.50 0.002	- -	2.17 -	- -	0.33 -	3.00 -	- -	- -	- -	- -	436	1.08	0.178
Freshwater R.	6	Spring/85	6	18.33 0.05	0.33 -	13.83 0.04	9.17 0.06	1.50 -	131.00 0.02	0.17 -	- .	1.50 -	- -	1.33 -	0.17 -	- -	10.00 0.01	- -	- -	- -	0.17 -	188	0.17	0.024
Northeast Bk.	St 1	Spring/85	6	10.67 0.06	0.67 0.02	2.33 0.04	12.33 0.10	42.67 0.07	83.83 0.01	1.67 -	1.33 0.01	2.67 -	- -	2.50 -	0.33 0.02	0.83 -	1.67 -	- -	- -	- -	- -	164	0.32	0.046
Northeast Bk.	St 3	Spring/85	6	40.83 0.13	1.17 0.01	14.33 0.05	9.33 0.05	11.33 0.01	111.50 0.003	9.33 0.01	2.50 0.02	9.33 0.01	- -	3.17 -	- -	9.00 -	- -	- -	- -	- -	0.83 -	223	0.28	0.028
Northeast Bk.	St 4	Spring/85	4	23.75 0.13	4.25 0.06	4.00 0.01	35.75 0.30	46.75 0.14	68.50 0.01	2.75 -	0.25 0.002	1.50 -	- -	6.75 -	0.25 -	2.00 -	- -	- -	- -	- -	0.25 -	197	0.64	0.099

*Samplers are baskets, except for surber samplers.
**Surber samples.